CREDIT RATIONING IN KENYAN AGRICULTURAL HOUSEHOLDS AND UPTAKE OF RISK CONTINGENT CREDIT: EVIDENCE FROM THE FIELD

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ABSTRACT

There is an increasing focus on the potential for financial products to improve the welfare of smallholder farmers in developing countries. This paper reports on research conducted in the Machakos region of Kenya to understand the credit rationing status of smallholder households and the potential of a novel financial product, risk contingent credit (RCC), to open access to credit markets for households who may have previously voluntarily withdrawn from the credit markets. We find that households do not show a preference for RCC as compared to a normal credit offering, but that the intervention did lead to quantity and risk rationed households acting in a similar manner to the price rationed households. These findings highlight the importance of extending credit access to agricultural smallholders and point to the need for further research into RCC.

BIOGRAPHICAL SKETCH

Seth Olson was born in Bend, Oregon in 1992 and grew up in Newark, Delaware where he developed a deep affinity for the natural environment. He pursued his undergraduate degree at the University of Delaware and graduated in 2015 with a B.S. degree in Natural Resource Management, minors in Resource Economics and Wildlife Conservation, and great memories. At Cornell, he pursued an M.S. degree in Applied Economics and Management, was a CIPA Environmental Finance and Impact Investing Fellow, and managed the secretariat for the Coalition for Private Investment in Conservation. In his free time, he can be found enjoying the company of friends, trying new beers, exploring/enjoying the great outdoors, and reading in his hammock when the Ithaca weather allows.

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LIST OF ABBREVIATIONS

- DEM – Direct elicitation method
- IFPRI – International Food Policy Research Institute
- RCC – Risk contingent credit
- RCT – Randomized control trial
- SATISFy – Satellite Technologies Innovative and Smart Financing for Food Security

CHAPTER 1

INTRODUCTION

There is a global shift underway. Over the last 10-15 years, there has been a growing number of entrepreneurs, impact investors, foundations, and development finance institutions focused on delivering market-based, profit-generating, socially and environmentally sustainable solutions to people living at the base of the economic pyramid (Dassel and Cassidy, 2017). Inspired by the global commitments to achieving a sustainable future, such as the Sustainable Development Goals and the Paris Climate Accord, there are a group of these individuals and institutions that are focused on increasing productivity, resilience, and well-being of smallholder farmers across the planet. Many of the solutions focus on increasing access to financial services such as credit and insurance, as access to financial markets has been found to help overcome barriers that may trap households in poverty (Skees and Barnett, 2006). While microfinance has a rich history dating back to the founding of Grameen Bank in 1983, there has been limited success in using microfinance to improve the livelihood outcomes of the rural, agrarian poor who are often locked out of markets and only produce for subsistence. However, there has been an increasing recognition that agricultural credit markets and insurance markets need to be developed together (Karlan et al., 2014) to deliver their intended impacts.

This paper reports on two analyses using data from an ongoing randomized control trial (RCT) in Kenya of a novel financial product that links index insurance to microfinance loans with the aim of opening access to credit markets for households that have positive notional demand for credit, but no effective demand due to aversion

to the risk of collateral loss. The first analysis is on the determinants of a household's credit rationing status. Credit rationing refers to a household either not having access to credit markets due to supply-side constraints, or choosing not to access credit markets due to non-price terms of the loans. The second analysis looks at loan uptake across the various credit rationing groups and the different credit products offered during the RCT.

Until recently, most literature on credit rationing in rural agricultural markets has been limited to the examination of supply-side constraints, called quantity rationing, (Bell et al., 1997; Carter, 1988; Carter and Olinto, 2003; Hillier and Ibrahimo, 1993; Jaffee and Stiglitz, 1990; Kochar, 1997; Barry et al., 1981), whereby a household faces a credit market that is constrained and have their loan application rejected, or failed to apply due to belief that they would be rejected. Barry et al. (1981) define credit risks as "unanticipated variations in the costs and availability of credit that arise from forces in financial markets or from lenders' responses to risks in agricultural markets and farmers' creditworthiness." This stops short of considering consumers' response to both environmental factors (environmental here meaning both the actual environment and the economic environment) and the non-price terms of loan contracts.

However, increasingly there is evidence of other types of rationing affecting participation in the credit markets (Boucher and Carter, 2001; Boucher et al., 2008, 2009; Guirkinger and Boucher, 2008; Verteramo Chiu et al., 2014). Unlike the households that are denied access to the credit market, and therefore quantity rationed, some may voluntarily withdraw due to the non-price terms of contracts available to them such as the required transaction costs (e.g. time, if bank is far away), or collateral requirements (e.g. having to put up land title) (Boucher et al., 2009; Guirkinger and Boucher, 2008). Risk rationing and transaction-cost rationing arise when the limiting

constraint comes from the demand side, and these types of credit constraints are especially important to understand because the policy strategy for their alleviation differs from a strategy designed to eliminate quantity rationing (Boucher et al., 2009; Karlan et al., 2014).

One novel strategy to remove the constraints of risk-rationed farmers is called risk contingent credit. While similar structures have been developed and discussed (Giné and Yang, 2009; Karlan et al., 2011; Miranda and Gonzalez-Vega, 2011; Skees and Barry J. Barnett, 2006), risk contingent credit (RCC), as developed by Shee and Turvey (2012) is "a general term we use for any credit instrument that embeds within its structure a contingent claim which when triggered transfers part or all of the borrower's liability to the lender or integrator/counterparty." Such an instrument can theoretically substitute for collateral, opening access to the credit markets for those who have an investment opportunity with expected positive profit, but who voluntarily withdraw from the market due to the negative utility associated with risk of collateral loss. Liquidation of productive assets, such as real estate and livestock, can be especially damaging to a household's future wellbeing (Carter and Barrett, 2006; Barry et al., 1981), and therefore it makes sense households may be especially risk-averse to losing these assets. In the context of agricultural loans, productive assets are often the required collateral. Risk contingent credit, therefore, removes the constraints stopping a risk rationed household from utilizing the credit market to enhance productivity and well-being, while providing a safety net should an outside event threaten productivity and well-being. This product is especially promising because it is unlikely that credit and insurance markets can develop effectively on their own in developing countries with little agriculture financial infrastructure in place (Carter et al., 2011; Karlan et al., 2014).

In the product this study focuses on, the contingent claim is based on an index, not an assessment of actual losses. There are both benefits and challenges associated with index, or parametric, insurance relative to more traditional indemnity-based insurance. Some of the problems index insurance helps alleviate include moral hazard, adverse selection, and high administration costs (Miranda and Gonzalez-Vega, 2011). The combination of these factors make index insurance much less expensive, and therefore accessible, than traditional insurance products for poor households. The main detraction of index insurance is the introduction of basis risk, which is the potential variation and mismatch between index measurements and actual losses (Marr et al., 2016). Therefore, it is important to have a trustworthy index which is highly correlated to agricultural losses. In the context of agricultural production in Kenya, where drought is the greatest source of covariate risk and which has seen an increasing number of weather shocks recently (Funk et al., 2010), the most popular index is local cumulative rainfall.

In order to fully understand the implications of an expanded understanding of credit rationing that includes both supply and demand-side constraints, the potential of RCC and to place the results of the reported analyses in context, we will now present a brief background on Kenya's agricultural economy and credit access.

Kenya's geography consists mostly of arid lands (70%), with semi-arid lands accounting for an addition 19% of the land surface. That leaves 11% of land in a "high-potential" category and 62% of the country's population lives on this 11% of land (Oluoch-Kosura, 2016). In 2016, agriculture accounted for 36% of Kenya's GDP, while accounting for 61.1% of total employment (World Bank, 2018; Oluoch-Kosura, 2016). Food accounts for 52.9% of the country's exports. However, 80% of farmers are categorized as subsistence farmers and do not contribute any production into local, regional, or national markets (World Bank, 2013). On top of the production, market,

and institutional challenges that Kenya faces in its agricultural development journey, the country has seen an increasing number of weather shocks, such as drought, that impact smallholder farmer's vulnerability (Oluoch-Kosura, 2016; Funk et al., 2010). Importantly for Kenya's overall economic growth strategy, there is a tight correlation between the country's GDP growth rate and the growth rate of the agricultural sector (Oluoch-Kosura, 2016). The agricultural sector's growth is inhibited by smallholder credit rationing and lack of easily accessible risk management strategies, such as insurance.

Now we turn to credit access and usage in Kenya. In 2016, an estimated 34% of the country's population had an open loan. However, only 15.6% of those were from formal sources with the remaining coming from informal sources such as social networks and community groups (FSD Kenya, 2016). Nasr (2017) found that Kenyans rely heavily on these informal loans and that the formal credit market does not increase the usage of other services, such as technical assistance or extension services. This raises a question as to the reasoning behind the lack of usage of formal credit. Is informal credit preferred to formal credit? If so, then introducing new formal credit products may not be the most effective route to increased wellbeing and decreased vulnerability of the targeted population. This does not appear to be the case because there is strong evidence pointing to pent-up demand for formal credit (Nasr, 2017). The results of the uptake analysis reported in this paper corroborate that evidence as well.

Narrowing the scope, the study that informed the analyses reported in this paper was conducted in the Machakos county in Kenya. Machakos has hilly terrain, a semi-arid climate, is located in the southwestern region of Kenya, and borders Kenya's largest city and capital of Nairobi (Figure 1). Maize is the main food crop produced by smallholder farmers in the county. The survey population consists of a

subset of 1,170 agricultural households. In order to maximize the generalizability of the results and increase variation in the survey population, the sample was selected from 13 locations dispersed among five sub-counties of Machakos. Within each location, there were six villages randomly selected and 15 households of each village were then randomly selected to fill out the sample size (Table 1).

Figure 1: Map of Kenya with Machakos County highlighted.

Sub-County	Location	Households surveyed
Kangundo	Kanzalu	90
	Kakuyuni	90
Kathiani	Mitaboni	90
	Kathiani	90
	Iveti	90
Matungulu	Kyanzavi	90
	Matungulu	90
	Tala	90
Mwala	Mbiuni	90
	Mwala	90
	Masii	90
Yatta	Matuu	90
	Kithimani	90
Total		1170

Table 1: Breakdown of households in survey among the sub-counties and locations.

On average, the households surveyed were headed by individuals who were 56.2 years old who had completed 8.6 years of formal schooling. 21% of households were headed by a female. The average household had 5.7 members where 30.2% of members' primary activity was crop production. The only higher primary activity was schooling, with 36.8% of survey population being students (Figure 2). Within the survey sample, households on average tended to four acres spread over two plots. Ownership of land was very high, with 94% of plots farmed being owned by the household that was tending to the plot. Table 2 shows the mean and standard deviations across the rationing groups of the socioeconomic and production variables used in the analysis of determinants of credit rationing status.

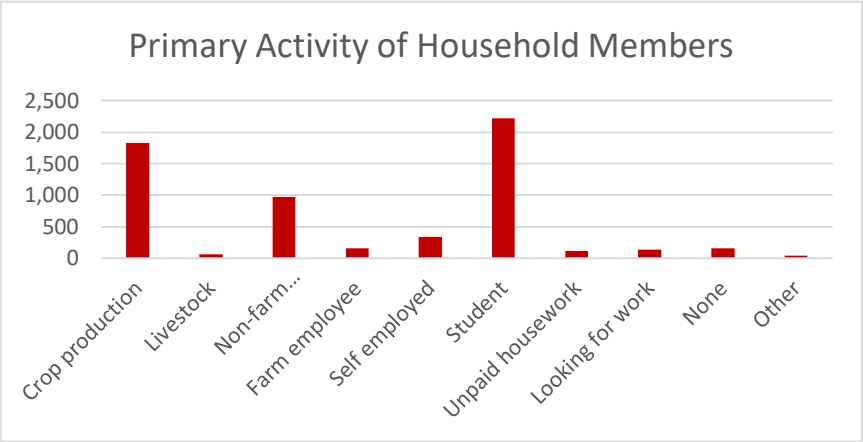

Figure 2: Breakdown of household members primary activity.

Since the goal of RCC is to open access to credit markets for the credit rationed, it is important to understand the ration status of any population where the instrument is introduced. The background survey that informs the first analysis presented below not only included questions on socioeconomic and production characteristics of the households, but also included a section that utilized a direct elicitation method to categorize households between the four types of ration status, price, quantity, risk, and transaction cost rationed.

It is obvious that including demand-side rationing (risk and transaction cost rationed) is important for policy and or market solutions to increasing smallholder wellbeing as they make up 43.3% of the survey sample (Figure 3). It's easy to imagine that underestimating the credit constraint status of a population by 43% would lead to inefficient and non-optimal policies.

	Price rationed		Quantity rationed		Risk rationed		Transaction cost rationed		Total	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
age	55.50	13.20	55.70	12.90	56.80	13.40	58.20	12.30	56.20	13.20
education	9.30	3.80	8.70	3.80	7.90	3.80	7.90	3.70	8.60	3.80
female	0.20	0.40	0.20	0.40	0.30	0.40	0.20	0.40	0.20	0.40
hh_adults	3.60	1.60	3.60	1.60	3.50	1.70	4.10	1.80	3.60	1.60
hh_size	5.70	2.30	5.90	2.30	5.70	2.40	6.30	2.70	5.70	2.30
total_acres	4.80	10.50	3.70	5.60	3.10	3.70	3.40	3.00	4.00	7.80
maize_per acre	270.80	262.70	235.60	292.70	238.80	202.80	221.60	171.30	252.50	241.30
plots	2.00	1.10	1.80	1.00	1.90	1.10	2.00	1.30	2.00	1.10
ownership	0.90	0.20	0.90	0.20	0.90	0.20	0.90	0.20	0.90	0.20
ave_dist	1.60	0.60	1.60	0.60	1.60	0.60	1.60	0.60	1.60	0.60
productive assets	10.30	15.40	7.20	8.00	6.80	7.20	9.50	10.20	8.60	12.00
l_income	1.90	8.50	1.00	2.60	0.80	2.70	0.40	0.90	1.40	6.10
percent food	0.50	0.20	0.50	0.20	0.50	0.20	0.50	0.20	0.50	0.20
sub_welfare	2.90	0.60	2.70	0.70	2.70	0.60	2.60	0.60	2.80	0.60
risk aversion	2.50	1.20	2.50	1.20	2.40	1.10	2.40	1.20	2.40	1.20

Table 2: Breakdown of mean and standard deviation of variables used in analysis by rationing status

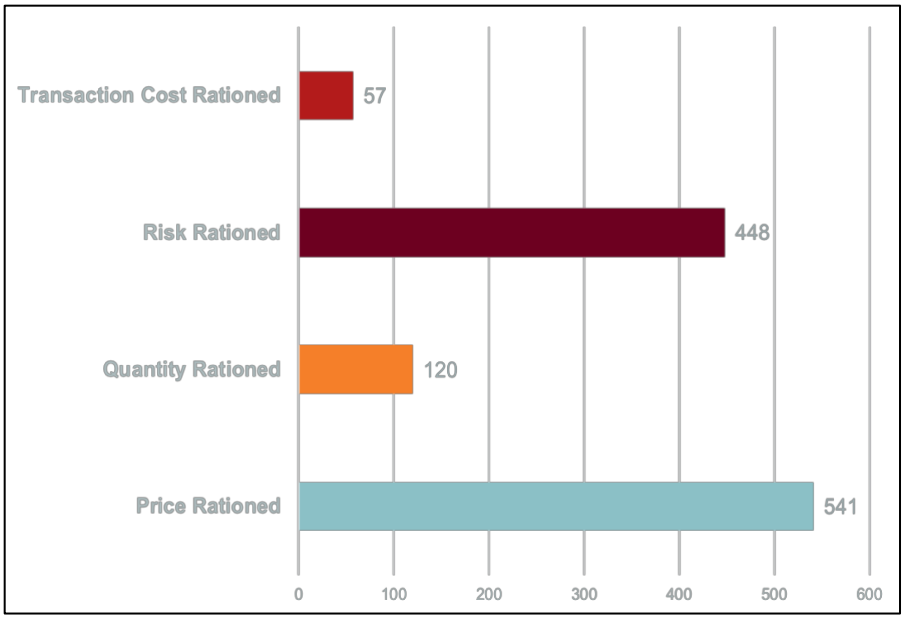

Figure 3: Breakdown of household's ration status for those participating in survey and RCT.

The rest of the paper is as follows. Chapter two reviews the relevant literature needed to understand the reasoning for, mechanics of, and applications of risk contingent credit, with details on credit constraints/rationing, index insurance, a review of structures similar to RCC, and a review of studies that also utilized a DEM to understand credit rationing. Chapter three describes the methods including a description of the SATISFy project this analysis is part of, details and logistics of the RCT, the direct elicitation methodology used to collect the data, and the empirical strategy of each analysis. Chapter four reports the results of the analyses. Chapter five is a discussion of results and implications for the growing number of organizations and enterprises focusing on increasing financial inclusion among those at the base of the economic pyramid. Chapter six concludes.

CHAPTER 2

LITERATURE REVIEW

Credit Constraints and Rationing

In this section, we will seek to understand the concepts of credit constraints and rationing broadly, and then dive into an explanation of each of the four credit rationing groups. The terms credit constraints and credit rationing inherently suggests that these phenomena negatively impact households. Indeed, it has been empirically shown that credit constraints have negative effects across both production and livelihood choices of smallholder farmers. In one study, the choices that credit constraints negatively impact included food consumption, input applications, health, and education (Kumar et al., 2013). Another study finds that credit constraints lower the value of agricultural production in a region by 26% (Guirkinger and Boucher, 2008). That same study showed that agricultural productivity was tightly linked with a household's endowment if they were credit constrained, but was independent of a household's endowment if they were not credit constrained. This is further evidence that credit constraints impact production choices. When a household's credit is constrained in the formal markets, there is a chance that they will spill-over into unregulated, informal markets in search of credit (Bell et al., 1997; Boucher and Guirkinger, 2007). The informal market could be made up of friendly lenders, such as family, friends, and neighbors, or predatory lenders. However, Boucher and Guirkinger (2007) show that the informal sector loans may be better equipped to smooth consumer consumption due to lower collateral requirements. This suggests that in some scenarios unconstrained households may choose to borrow from the informal sector due to lower collateral requirements.

It was determined in the 1980's that liberalization of credit markets would not be enough to provide equitable access to credit markets for smallholder farmers as adverse selection could cause banks to endogenously impose restrictions that ration farmers out of the market (Carter, 1988). Jaffee and Stiglitz (1990) give an early, detailed treatment of credit rationing and provide four definitions of different types of credit rationing. However, the constraints all come from the (lack of) supply of credit. In Jaffee and Stiglitz's typology the four definitions of credit rationing were as follows. *Interest rate (price) rationing* is the same as in our typology where a borrow makes a trade-off between size of loan and interest rate. *Redlining* is similar to our typology of quantity rationing whereby a lender will not borrow to a potential borrower at any interest rate. *Pure credit rationing* describes situations where apparently identical individuals who are willing to borrow are offered loans with the same terms however some are able to borrow and others are not. In the situation of pure credit rationing, changes to the availability of credit will be more beneficial than changes in the interest rates. Of Jaffee and Stiglitz's typology, *divergent views rationing* is the closest to addressing demand-side constraints. In divergent views rationing, some potential borrowers feel their interest rates are not reflective of their true probability of default and choose not to borrow on those terms (Jaffee and Stiglitz, 1990). It is important to note that Jaffee and Stiglitz were focused on the US for their analysis and that a lack of financial literacy would potentially prevent smallholder farmers from making the judgement call in divergent view rationing. One advantage of the DEM survey method described below and utilized in this study is that it allows for us to understand the thoughts behind action or non-action in the credit market and not only the household's actions.

What causes credit constraints and rationing to arise? First, it is important to understand that credit markets are different from standard markets for goods. Credit

markets rely on a promise of repayment instead of payment on the spot for a good. The temporal element of credit adds uncertainty to the probability of repayment and in credit contracts the interest rate represents what the borrower promises to repay, not what they will actually repay (Jaffee and Stiglitz, 1990). This leads to credit contracts that are multidimensional, not purely reliant on the interest rate to secure the lender's income (e.g. enforcement and collateral collection agreements in the credit contracts).

The uncertainty in credit repayment is not the only issue leading to a potential for credit rationing. In a model world that is perfectly competitive, where information is symmetrically distributed, and enforcement is costless, credit contracts could be written conditional on borrower behavior (Boucher and Carter, 2001). We do not live in this model world though, and asymmetric information and positive enforcement costs have the potential to lead to adverse selection and moral hazard problems which restricts the set of available contracts (Boucher and Carter, 2001; Hillier and Ibrahimo, 1993; Jaffee and Stiglitz, 1990). Information asymmetries can lead to adverse selection whereby households with higher than average risk of default opt into credit, while those with less than average risk opt out, this increases the cost of credit across a lenders portfolio. Moral hazard refers to the possibility that there is a lack of repayment incentive due to unlikelihood of collateral collection or other consequence being felt by the household.

That this restriction adversely effects the households we label as quantity rationed has been well covered by the literature, with the discussion of rationing focusing on supply-side constraints and policies to reduce the frequency of quantity rationing. This is done mainly via land titling programs with the idea that the households will then be able to borrow against their titles, however titling has been found to only increase credit supply for a subset of wealthier households (Carter and Olinto, 2003). Additionally, Boucher et al (2008) find that titling may reduce quantity

rationing but with the tradeoff of increasing risk rationing. However, demand-side constraints also reduce credit market participation so we need to understand both supply and demand-side constraints in order to develop optimal policies for rural agricultural finance.

Now we define the various ration statuses, starting with the more traditional price and quantity rationed and finishing with more recently explored demand-side constraints of the transaction cost and risk rationed. We will dwell longer on the theoretical understanding of risk rationing as RCC is specifically designed to alleviate this constraint.

Price rationed, or unconstrained households can be either borrowers, who are satisfied with the loan amount at the price offered (this is referred to as external price rationing), or non-borrowers, who voluntarily chose not to enter credit markets even when faced with fair market prices and transaction costs (internal price rationing) (Verteramo Chiu et al., 2014). In general, households that are price rationed are those that interact with the credit market in the expected way, entering the market to finance a profitable investment project that they do not have the liquidity to self-finance. In this context, price rationing is determined by cost-quantity tradeoffs along the demand curve, where Verteramo Chiu et al. (2014) show individual credit demand elasticities affect the degree by which such tradeoffs take place.

The other three categories of credit rationing, the non-price rationed households, are those that would like to borrow money at the going interest rate but could not qualify for the loan, are not willing to pay transaction costs on the loan, or are afraid to lose collateral (Boucher et al., 2008). As already touched on in the introduction, quantity rationed households are those that are supply-side constrained. These households have had a loan application rejected, been offered a loan of an amount less than they applied for, or have not applied for a loan due to the belief that

they would be rejected. Quantity rationed households face binding credit limits and therefore should be expected to have excess credit demand (Verteramo Chiu et al., 2014). More technically, in the presence of asymmetric information a lender will restrict the set of interest rate/collateral pairings they are willing to trade between, setting some minimum sufficiently high collateral (Boucher et al., 2009). This restriction of feasible contract sets means that a household has a profitable project, and therefore positive *notional* demand for credit, but faces zero credit supply. This mechanism is what gives rise to quantity rationing due to supply-side constraints.

Within this framework for understanding credit rationing status, there will also be households that face constraints on the demand side, which limit market participation. These households will have positive notional demand and face positive supply but may not show any effective demand. Effective demand is the demand for contracts available in the real world of asymmetric information, those contracts that are within the restricted available contract space (Boucher et al., 2009). Both households that are supply side (quantity) rationed and demand side (risk and transaction cost) rationed would be able to undertake projects with expected positive returns in the first best world of symmetric information. However, in the real world of imperfect and asymmetrical information, both groups undertake low return, safe labor activity (Boucher and Carter, 2001).

The last two types of credit rationing status define those who have a positive notional demand but may not have positive effective demand. There have been several studies that that have pointed this out (Boucher et al., 2008, 2009; Jappelli, 1990; Mushinski, 1999); because of the restriction of possible contracts due to asymmetric information, a household may have both positive notional demand and face positive supply but has no effective demand for available contracts. A key driver that will lead a household to have no effective demand for credit even when they have positive

notional demand and positive supply is the inclusion of collateral requirements in the credit contracts. This shifts the risk profile of contracts and increases transaction costs. Transaction-cost rationed describes those households that face zero effective demand due to the size of the transaction costs associated with the loan, such as distance/time to local bank branch, amount of paperwork required, and self-evaluation of the opportunity cost of pursuing a credit contract.

The concepts that underpin risk rationing have a long history, and they point to the theoretical advantages of risk contingent credit. Many studies have found that farmers are willing to pay a premium in order to avoid the potential for collateral loss (Binswanger, 1980; Binswanger and Sillers, 1983; Carter, 1988; Eswaran and Kotwal, 1990). In an early precursor to the risk rationing concept, Binswanger and Sillers (1983) suggest that farmers may withdraw from credit markets even if they are eligible for their desired loan if they are faced with uninsured contractual risk.

Risk rationed describes the households that show lower effective demand due to the risk-sharing rules of the contract, usually dealing with collection of collateral in the event of default (Verteramo Chiu et al., 2014). Boucher et. al. (2008) define risk rationing as occurring "when insurance markets are absent, and lenders, constrained by asymmetric information, shift so much contractual risk to the borrower that the borrower voluntarily withdraws from the credit market even when she has the collateral wealth needed to qualify for a loan contract." This increase in contractual risk acts in a similar manner to an increase in interest rate to equilibrate the credit market by reducing demand. However, credit markets are infrequently in equilibria as there is often excess demand for credit (Jaffee and Stiglitz, 1990).

The collateral requirement forces the household to bear a minimum amount of risk and the inclusion of this risk in their expected utility calculation drives the borrower's expected utility below their reservation utility, even though the loan would

raise expected consumption (Boucher et al., 2009). This last point, the difference between expected utility and expected consumption is critical to understanding the plight of the risk rationed.

It is worth noting insights from prospect theory here. Most households are risk averse, and they are making decisions under uncertainty. They will make judgements about accepting credit based on the relative gains and losses associated with their choices and not on their potential absolute wealth level that results from their choice. If we accept prospect theory, their value functions will be steeper for losses than for gains (Kahneman and Tversky, 1979). This explains why their expected utility can be lower if they accept an economically fair credit contract that includes the potential for collateral loss. They weigh this loss more than the potential upside from their increase in expected consumption and therefore reject the credit contract.

The analysis of credit constraints and credit rationing has a long history. Until recently though, the impact of demand-side constraints and rationing has not received as much attention in the literature, and therefore, there are not as many policy interventions focused on relieving these constraints. This has been changing, and we now have a better understanding of the mechanisms that underlie risk and transaction cost rationing. Risk contingent credit is one novel intervention designed to open credit markets to the risk rationed. It's potential relies on an embedded contingent claim, an index insurance contract. We will now explore the literature around index insurance in more depth.

Index Insurance

There has been a growing interest in the application of index insurance to alleviate pressures on the rural, agrarian poor in developing countries and there is a lively debate about the optimal use of the emerging tool in this context (Tadesse et al., 2015; Turvey, 2011). The inclusion of an embedded index insurance claim is one of

the innovative features of risk contingent credit, and as such is it important to understand what exactly index insurance is, its benefits and challenges, and generally the literature concerning its usage in development contexts. We will review these areas over the following pages.

Insurance allows agricultural households to make an ex ante investment to smooth income/consumption in the event they experience a negative shock (Skees and Barnett, 2006). Index insurance is different than classic insurance schemes in that potential pay outs are not tied to an evaluation of actual losses at the household level, rather they are tied to the outcome of an index over a predetermined period of time relative to a specific trigger on the index. Index insurance is designed to handle covariate risks that will effect a large geographic area or population. Unlike idiosyncratic risks that may arise out of farmer practices such as input use and land stewardship, covariate risks will likely effect an entire village or county. As such, there are different determinants of demand for index insurance relative to traditional insurance (Marr et al., 2016). On the one hand, index insurance is cheaper and easier to deliver to areas that have previously been thought of as uninsurable but on the other hand index insurance has greater uncertainty and variation between actual losses and the index trigger. This opens the door for basis risk. The term basis risk is used to describe the lack of perfect correlation of actual losses and a calculated index and is one of the main challenges faced by index insurance programs to date (Tadesse et al., 2015).

As basis risk is such an important issue for implementing index insurance programs, the selection of an appropriate index is incredibly important. Ideally, an index should be a random variable that is based on timely, objective, transparent, measurable, and independently verifiable data that is experienced over a (relatively) large geography, highly correlated with losses, and cannot be influenced by any

actions of the insured (Alderman and Haque, 2007; Miranda and Gonzalez-Vega, 2011). Some indices that have been employed to date include total rainfall, temperature, area-yield index, vegetation indices, regional livestock mortality rates, and El-Nino indices (Greatrex et al., 2015; Miranda and Gonzalez-Vega, 2011; Tadesse et al., 2015). While these indices are all posited to have a causal relationship with potential losses, it is worthwhile to note that an index's relationship to losses need not be causal, rather the important feature is the statistical correlation between the index and losses. However, weather-related risks are instrumental in determining livelihood outcomes for smallholder farmers and as such most indices suggested to date are focused on weather events or the outcomes of weather events (Alderman and Haque, 2007).

Many indices that have been utilized to date that have struggled with basis risk are simple rainfall triggers (Gommes and Göbel, 2013). They are often used because of their simplicity and transparency, which are highly desired features of insurance contracts, especially for households with limited financial literacy. However, there has been increasing interest in more complex (but more accurate across both yield and spatial considerations) indices that take into account more data than cumulative rainfall (Gommes and Göbel, 2013; Muneepeerakul et al., 2017). In the final discussion of this paper, we will dwell on the consideration of more complex indices as the RCT associated with this study ran into basis risk issues using a cumulative rainfall trigger without accounting for frequency and intensity of the rain.

Why is there so much excitement around index insurance's application toward solving wicked development challenges? One reason is that the technologies to efficiently calculate trustworthy indices are becoming more readily available and better understood/trusted. Such technologies include satellite imaging, remote sensing, and IoT (Internet of Things). While the technology is the key enabler of index

insurance, its ability to avoid/nullify key constraints that have hampered credit and insurance in rural markets are the truly exciting features. Index insurance's advantages include its low administrative costs (insurers do not have to collect household level data on losses), the elimination of moral hazard (the insured cannot influence index value), and being free of adverse selection issues (contract and premium based on publicly available data) (Marr et al., 2016; Miranda and Gonzalez-Vega, 2011). By eliminating these potential constraints to insurance delivery, it is hoped that households will move away from reservation, low yield/risk strategies and toward riskier strategies that have the potential to raise productivity, income, and consumption when they are protected against downside losses via an ex ante insurance investment.

As hinted to a few times in this section so far, for all of their potential, index insurance schemes also have faced significant challenges in development contexts (Tadesse et al., 2015). On the institutional side, insurers may struggle to pool covariate risks into portfolios because, by definition, covariate risks are highly correlated and the less correlated risks in an insurance portfolio are, the lower its overall variance. This can be handled by transferring the risk through reinsurance into secondary markets, however, reinsurers may struggle to audit contracts, leading to loading charges and higher premiums (Alderman and Haque, 2007). Additionally, Alderman and Haque (2007) bring attention to the fact that risks are hard to quantify in changing climatic, political, and economic environments and historical data may not provide true guidance for development of appropriate indices and triggers.

The largest challenge of index insurance though is undoubtedly the creation of basis risk. There are two types of basis risk, production and geographic basis risk. Production basis risk refers to the probability that indices and their triggers are not tightly correlated to damages. Geographic basis risk refers to the probability that the index being tracked is different between the insured's location and the data collection

location, which are usually rain gauges (Muneepeerakul et al., 2017). In an attempt to make indices easy and transparent, index insurance schemes may increase basis risk, particularly production basis risk because cumulative rainfall (a common index used) does not account for the important impact that rainfall frequency and intensity have on yield outcomes (Gommes and Göbel, 2013). As an example, in our study in the Machakos region of Kenya there were significant damages, but the cumulative rainfall was above the insurance trigger because the rain fell infrequently but in large quantities when it did.

This is a huge issue for the potential growth of index insurance as a risk mitigation strategy for farmers in developing countries. When farmers are introduced to the product, it is assumed that in the event of drought, or other negative event the insurance is linked to, they will receive their payout. In the event that they experience losses and are not compensated it is likely they will lose trust in the insurance product, and potential financial markets more broadly. In a series of experiments in Ghana, Karlan et. al (2014) found that demand for insurance in subsequent years after first launch was positively associated with farmers and their neighbors receiving payouts.

There have been multiple studies completed looking into the use of index insurance for agrarian households in developing countries beyond the Karlan et. al (2014) paper. We will now review a few key findings of these studies before moving on to the next section of the literature review. First, in the Karlan et. al (2014) study they found high demand for index insurance, and that those households who accepted insurance did indeed invest significantly larger amounts into their agricultural operations and made riskier production choices. Secondly, Marr et. al (2016) conducted a systematic review of the literature around the adoption and impact of index insurance and credit for smallholder farmers. They found that *stated* demand for index insurance could be very substantial, with up to 90% of some study participants

wanting to pay for insurance. However, they found that actual demand was much lower, ranging from 2%-50% and the majority of studies indicating uptake of less than 25%. Third, as has been mentioned multiple times so far, there is evidence that neither the insurance market nor the credit market for agricultural households in developing countries are likely to develop on their own (Carter et al., 2011; Karlan et al., 2014; Tadesse et al., 2015). These findings are one of the reasons for the recent proliferation of studies looking at the potential for linked insurance-credit products, such as risk contingent credit, to help alleviate the struggles of the targeted populations.

Finally, it is worth pointing out that most of these studies on index insurance to date have focused on marketing the insurance at the household level. One paper looked at marketing insurance at a higher level on the financial value chain, targeting banks than make microloans to agricultural households because the bank's basis risk is lower (Farrin and Miranda, 2015). They find that giving the banks first claim on payouts can reduce interest rates and therefore increase access to credit. The optimal point for insurance along the MFI value chain is an area that deserves more analysis in the literature.

The interest in utilizing index insurance to increase the livelihood outcomes of agricultural, poor households in developing countries is deserved. However, the indices used to trigger payouts need to be carefully considered and potentially made more complex to reduce basis risk and insurance markets should be developed in unison with credit markets, if not marketed together in bundled products, in order the maximize index insurance's impacts.

Review of Similar Structures

As mentioned in the previous section, there has been a recognition for a few decades that some farmers may withdraw from credit markets even though they are eligible for a loan in the face of uninsured contractual risk (Binswanger and Sillers,

1983). Prior to the exploration of products that bundle index insurance and credit that has mainly happened over the last decade, there were earlier efforts to lower the risk of agricultural loans. We will quickly review these, namely commodity-linked instruments, before going over studies that report on more recent experiments on bundled products.

A very early predecessor to insurance linked credit products is the commodity bond. Commodity bonds are different from traditional bonds because instead of paying nominal interest rates and repaying principle along a determined schedule, the commodity bond pays off in stated quantities of a commodity (e.g. gold, cotton) (O'Hara, 1984). It was proposed that commodity bonds were valuable because they provide a form of insurance. However, O'Hara (1984) showed that while they do protect against relative price changes, the mechanism introduces greater variability into future real income streams thereby reducing the viability of the bonds to provide price insurance for future consumption.

An evolution of the commodity bond is the commodity-linked loan. These loans have a payoff structure that includes an embedded option rider on the underlying commodity and therefore allows the loan repayment structure to be contingent on the price of the commodity (Jin and Turvey, 2002; Turvey, 2006). These loans can be used to hedge financial risks that arise when a firm faces unfavorable business risk, however the studies around them focus on developed markets, and it is not clear that they could be used in a microcredit context effectively, particularly in developing countries that do not have robust financial and commodity markets.

When we consider products specifically intended to increase the welfare of agricultural households in developing countries it has become clear that insurance markets and credit markets are unlikely to develop separately and therefore, bundled or linked insurance and credit products may be most effective in opening access to

financial markets for the targeted populations (Carter et al., 2011; Karlan et al., 2014; Marr et al., 2016). While little empirical research has been conducted on these bundled products (Marr et al., 2016), there have been two field studies of bundled products targeting farmers in developing countries we will now review. Before that though, it's worth noting we are focusing on crop farmers, not livestock herding/ranching. There have been studies that look at index based livestock insurance in Kenya, Ethiopia and Mongolia, but we do not report on those studies here (Chantarat et al., 2009; Greatrex et al., 2015).

First, we review a randomized experiment on price-indexed insurance-linked loans that was run in Ghana. In the experimental group, farmers were offered loans with an embedded indemnity component that would forgive 50% of a loan should crop prices drop below a trigger price while the control group were offered normal loans at the same interest rate (Karlan et al., 2011). This means that the insurance component was fully subsidized in this experiment. An interesting feature of their experiment is that they worked through existing banking infrastructure and farmers did not know that they were taking part in a natural field experiment. Therefore, those who participated in the study had self-selected into it by showing interest in taking out a loan. The study found very high take up across both treatments, 86% for the control product and 92% for the treatment product and that the indemnity had little impact on other outcomes of interest as well (Karlan et al., 2011). This suggests that the study population may have had highly inelastic demand for credit and were willing to accept a credit offer no matter the price or additional features (embedded price insurance). However, the fact that farmers self-selected into the experiment by showing up at a bank to ask for a loan may have biased the results.

Second, we report on a randomized field experiment conducted in Malawi in 2006 that sought to understand if the provision of insurance would induce farmers to

take out loans to adopt risky crop technology (Giné and Yang, 2009). In their experiment, around 800 maize and groundnut farmers were split into two groups, one which was offered credit for new hybrid high-yield seeds and one which was offered a similar credit package but also had to purchase a rainfall index insurance policy at actuarially fair rates that forgave the loan partially or fully depending on the cumulative rainfall outcome in growing season. Interestingly, in this experiment take up of the bundled product was 20% while take up of the uninsured credit product was 33% (Giné and Yang, 2009). They suggest that this result may be due to farmers already having implicit insurance in the form of the limited liability clause of loan contract and point out that uptake of the bundled product is positively correlated with education, income and wealth while this is not the case for uptake among those offered the standard credit product.

The results of these two field studies corroborate the initial findings of the RCT reported in this paper and suggest that while it is recognized that insurance and credit markets should be developed in unison, this is not a straight forward task and the desired effects of bundled insurance and credit products, mainly increased welfare of farmers, does not follow linearly from introducing a bundled product to a market. We will now move on to a review of the two studies that look into the determinants of ration status that include an examination of the risk rationed.

Review of Determinants of Risk Rationing Literature

To date, there have been two other studies that have utilized a direct elicitation method (DEM) in order to look into the determinants of a household's credit rationing status with a particular interest in the risk rationed (Boucher et al., 2009; Verteramo Chiu et al., 2014). These papers looked study populations in Peru, Mexico and China. Boucher et al. (2009) comment that the limited amount of empirical study of credit constraints can be attributed, at least partly, to the challenges of econometrically

identifying the impacts of credit constraints on households. However, they follow in the footsteps of Carter and Olinto (2003) and Jappelli (1990) in implementing the survey technique we are calling DEM. We will discuss DEM in greater detail in the methodology chapter, but it is important to note that these papers did use the same technique as we do to classify and partition the survey populations into their rationing groups. This increases the generalizability of the results.

We will first review Boucher et al. (2009) who studied the determinants of credit rationing in Peru and also tested the validity of using DEM in this line of research into risk rationing. To get the question of DEM validity out of the way, they do find that the method does allow for researchers to distinguish those households whose credit demands are most affected by risk. Before getting to the analysis of determinants of credit rationing status conducted in this study, another important analysis they conducted was an impact evaluation with and without the inclusion of the demand-side constraint categories. They found that inclusion of transaction cost and risk rationing lead to a doubling of the impact measure.

The analysis of the determinants of credit rationing status was conducted utilizing a multinomial logit and they report the marginal impacts of regression variables across five categories: price rationed borrowers, price rationed non-borrowers, transaction cost rationed, risk rationed, and quantity rationed. The variables used included: wealth, available labor, educational achievement, farm size, proportion of farmed land household held the title to, distance to nearest formal lender, a dummy to measure whether or not respondent could identify the minister of economics ("informed"=1) , variance of yields in district, a risk aversion measure and maximum level of informal credit available to household. Of particular interest were the following results.

- Unsurprising, the more wealth a household has the more likely they are to be price rationed. Wealth did not have an affect across the other rationing groups.
- Having a higher proportion of farm land titled led respondents being significantly less likely to be quantity rationed, transaction cost rationed, and price rationed non-borrowers and significantly more likely to be a price rationed borrower at the 5% level.
- The larger amount of family labor available to the household, the more likely they were to be transaction cost rationed while that was not significant across other groups.
- The farther from the nearest source of formal credit a household was, the less likely they were to be price rationed and the more likely to be risk and quantity rationed.
- The greater the yield variation around a household, the more likely they were to be either risk or quantity rationed.
- The greater the level of risk aversion, the less likely a household was to be a price rationed non-borrower and the more likely they were to be either risk or quantity rationed.

Moving on to the second paper that uses the DEM to analyze credit rationing status we will now discuss the results of Verteramo Chiu et al. (2014) who reported on studies conducted in both Mexico and China. They break rationing status into three groups: price rationed, quantity rationed, and risk rationed. Beyond analyzing the determinants of rationing status across socioeconomic and production variables, they also analyzed the effect of the elasticity of demand for credit across rationing status and found that that it does indeed differ across these rationing groups. They run multinomial logit, as well as individual bivariate logit and OLS models and they all

tell a similar story. Therefore, they report on the OLS results for ease of interpretation. As their regression analysis included variables for the varying levels of elasticity of demand, we will focus our attention here to only the socioeconomic and production variables included in their regression analyses. These include: sex, education, years of farming, farm size, income, percent of income from farming, asset value, savings, informal borrowing, formal borrowing, credit worthiness, entrepreneurship variables, prudence, and risk aversion. The following results are of particular interest:

- There are differences between the significance of the variables across the rationing groups in Mexico vs. in China, hitting home the importance of understanding the local conditions (culture, environment, economics, etc.).
- There was limited significance in the socioeconomic variables, however the formal and informal borrowing variables did correlate to the varying rationing statuses as theory would predict in China.
- The larger the household's asset value, the less likely they were to be quantity rationed and more likely they were to be price rationed in China, and the less likely they would be risk rationed in Mexico.
- The higher the risk aversion score, the more likely a household was to be risk rationed and less likely a household was to be quantity rationed in China.

Now, we will move on to a discussion of the methodologies used in the study reported on in this paper.

CHAPTER 3

METHODOLOGY

Context of SATISFy Project

The data for this research was collected in conjunction with an International Food Policy Research Institute (IFPRI) funded randomized control trial (RCT) of risk contingent credit (RCC) in Machakos county in Eastern Kenya as a part of a project called Satellite Technologies Innovative and Smart Financing for Food Security (SASTIFy). Machakos has hilly terrain and a semi-arid climate where maize is the main food crop produced by smallholder farmers. SASTIFy is a partnership between IFPRI and Equity Bank and looks to evaluate the viability of risk contingent credit as a market-based, innovative risk management solution/safety net to improve farmer livelihoods and mitigate drought risk. The project covered the growing season from October 2017 to March 2018 with pre and post surveys bookending the RCT.

The IFPRI study involves three main activities. First, a background survey of the 1170 randomly selected households who were chosen to participate in the randomized control trial of RCC. This survey is what informs the analysis of the determinants of a household's credit rationing status reported here. Secondly, the RCT is implemented whereby households were given access to normal credit, RCC at fair value, RCC with a 25%, 50%, or 75% subsidy, or be in the control group.

Experimental Group	Number of Households
Normal Credit	350
Fair Value RCC	350
RCC with 25%, 50% or 75% subsidy	120, 40 each
Control	350

Table 3: Breakdown of the survey population into experimental groups

The initial uptake results from the RCT have been collected and will inform the uptake analysis discussed later. Finally, there will also be a post-experiment survey conducted to gauge household reactions to RCC and delve further into reasoning for the uptake results and likelihood of product success in the market.

In order to maximize generalizability of the results of the study and to increase variation in survey population, the random sample was selected from 13 locations dispersed among five sub-counties of Machakos. Within each location, six villages were randomly selected with 15 households participating from each village. Table 4 shows the sub-counties and locations used in the study. The treatments are homogeneous across the locations with an equal amount of farmers receiving each treatment (control, normal credit, RCC, subsidized RCC).

Sub-County	**Location**	**Households surveyed**
Kangundo	Kanzalu	90
	Kakuyuni	90
Kathiani	Mitaboni	90
	Kathiani	90
	Iveti	90
Matungulu	Kyanzavi	90
	Matungulu	90
	Tala	90
Mwala	Mbiuni	90
	Mwala	90
	Masii	90
Yatta	Matuu	90
	Kithimani	90
Total		1170

Table 4: Breakdown of households surveyed by sub-county and location

The background survey was designed to capture two main categories of information. First, it collected information of socioeconomic variables on interest such as agricultural land and production data, demographic data, subjective welfare, and risk preferences. Secondly, it was designed to elicit the households' credit rationing

status. This process is described in greater detail after the following account of the technical details of the RCT.

Logistics and Details of the RCT

The randomized control trial (RCT) was implemented by Equity Bank starting in September of 2017. We will go over some key features of the RCT here in order to help the reader understand the logistics and important details of implementation. At the beginning of the project, Equity Bank employees met with local leaders at the village level in order to build support for the program and to encourage farmers to attend information sessions on RCC and general financial literacy. Then, over a ten-day period, training sessions with randomly selected farmers were conducted at each location.

Since households were chosen at random, there was variability in farmer's financial literacy and trainings were conducted in order to introduce farmers to banking and agricultural credit. After these general discussions, farmers were introduced to RCC and walked through the various details of the product, including the importance of insurance, level of premium, covered risks, and the loan application process. RCC was explained to the farmers through a game that illustrated the mechanisms and benefits of RCC relative to traditional practices with no credit and high productivity practices with credit. Prior research had found that this method of community engagement effectively explains RCC (Shee et al., 2015). There was also training on Good Agricultural Practices (GAP) and assistance from Equity Bank in opening accounts for those farmers who did not previously have an account.

One important characteristic of the loans the farmers were offered is their form. These loans were not distributed in cash in order to prevent non-agricultural usage. Rather, the loans were advanced to identified agro dealers' accounts and farmers were notified they could pick up their inputs from the dealer as soon as

possible. A second important fact is that the farmers had to be credit worthy in order to be extended a loan. All applications were submitted to branch credit committees for appraisal and farmers with a history of default were disqualified. One note from the distribution of loans is that while it was made explicit what form the loans would take, some farmers still expected to get cash and dropped out of the experiment after realizing this was not feasible.

One unfortunate hiccup in the RCT process is that project implementation was slightly delayed. Collection of repayment is on-going and we do not yet know repayment rates. We will discuss some potential changes in the future to RCC implementation in the discussion chapter. Now however, we move on to a discussion of the Direct Elicitation Method used to categorize farmers into credit rationing categories.

Direct Elicitation Method

In order to classify households' rationing status, a direct elicitation method (DEM) was used. This method has been modified and adapted from Boucher et al. (2009) and Verteramo Chiu et al. (2014) and is similar to the survey methods used for contingent valuation. The DEM is a series of questions based both on a household's experience and perception of credit since we are looking to assess demand-side (risk and transaction cost) and supply-side (quantity) rationing and the unconstrained (price). The structure of the DEM used in this survey is shown in Figure 4 and described below. Importantly, this structure allows for the rationing status to be determined from the households' self-reported information. The full questionnaire can be found in Appendix 1.

The DEM begins by dividing households into two groups, those that must formally request a loan and those that are offered unsolicited loans from local banks, cooperatives and grain buyers. If a household falls into this second group, they cannot

be quantity rationed as they have been offered credit. Respondents are then asked about the size of the loans offered, and if they accepted the full amount offered. In the case that the household accepts the full loan amount, they are classified as price rationed. If the household either did not accept the loan, or accepted less than the full amount of the loan, then they are asked a series of questions to determine the reason they did not accept the loan. If it is because they are afraid of losing collateral, then they are classified as risk rationed. If it is because the transaction costs are too high, then they are classified as transaction cost rationed.

In the first group, those who must formally request a loan, the next question is whether or not they have applied for a loan in the last two years. If they have applied, but either received no offer or an offer for a loan less than the amount requested the household is classified as quantity rationed, since the constraint is coming from the supply side. Households are categorized as price rationed if they either accepted the offered loan, or did not accept the offered loan due to risks associated with the contract. The remaining households are then categorized as risk or transaction cost rationed depending on their reasoning for not accepting the offered loan. The risk rationed cited fear of losing collateral while the transaction cost rationed cited high transaction costs. It's relevant to point out here that the households may know the lender's rules and applied for the qualifying amount. Finally, those that have not applied for credit in the last two years were sorted into their rationing categories based on their responses to questions on why they had not applied.

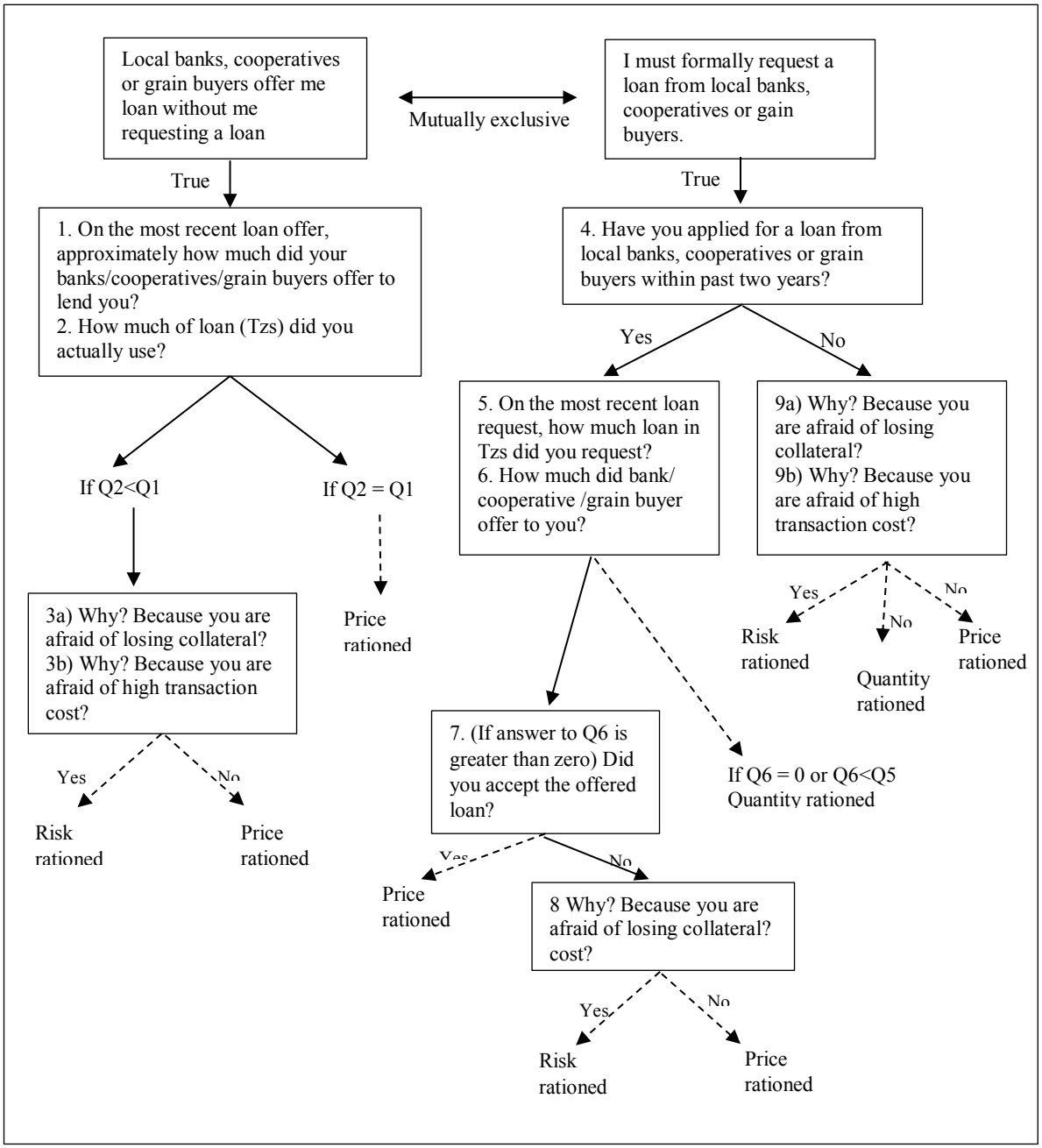

Figure 4: Schematic of the Direct Elicitation Method used to partition households into credit rationing categories.

After categorization, four observations are dropped after failing to fall into any of the predetermined rationing status categories. Checking the breakdown of rationing categories, the importance of studying the risk rationed is clearly evident, with 38.4% of the survey population being risk rationed. 46.4% of the survey population was price

rationed, with 10.3% quantity rationed and only 4.89% transaction cost rationed. These results are shown in Table 5.

Ration Status	Frequency	Percent
Price	541	46.4
Quantity	120	10.29
Risk	448	38.42
Transaction Cost	57	4.89
Total	1,166	100

Table 5: Frequency of each ration category among the surveyed households.

Next, we explain the empirical strategy and variable choice for the analysis of determinants of credit rationing status, and uptake analysis.

Empirical Strategy

In this section we will go over the empirical strategy for both analyses we conduct. First we well explain the strategy for the analysis of the determinants of household credit rationing status, then we will go over the strategy for the uptake analysis.

Determinant Analysis Methods

After successfully partitioning the survey population into ration status categories, we are able to utilize the socioeconomic and production data gathered by the background survey to analyze the determinants of credit rationing status. Since this analysis is concerned with the breakdown of households across the four rationing groups, it makes sense to simultaneously estimate coefficients through a multinomial logit. We drop the price rationed group to normalize the comparative results for the quantity, risk, and transaction cost rationed. In the model world, which we aim to achieve, all borrowers and non-borrowers are price rationed, so comparing the other

rationing groups to the price rationed group helps to simplify the interpretation of the coefficients. By leaving out the price rationed group the multinomial logit results answer the following question:

> *Relative to those households that interact with credit markets in an optimal way (from a systems perspective), is this ration group significantly more correlated with the variable in question, x_i?*

Following from Boucher et al. (2009), we use a simple single equation multinomial logit:

$$Y_{ij} = C + \beta_j' X_i + \varepsilon_{ij}$$

Where Y_{ij} is a categorical variable that represents the propensity of household *i* to be in rationing category *j*. β_j is a vector of parameters associated with *j*th rationing category and X_i is a vector of household *i*'s socioeconomic characteristics collected from the survey. In order to check for robustness and ease in interpretation of results, we follow Verteramo Chiu et al. (2014) and also run individual bivariate Logit models and linear probability models. These regressions take the form:

$$Y_i = C + \beta' X_i + \varepsilon_i$$

Where Y_i is a binary variable that represents the propensity of household *i* to be in the rationing group in question, β is a vector of parameters, and X_i is a vector of household *i*'s socioeconomic characteristics collected from the survey. All three of these models are run with robust standard errors clustered on the location level to account for unmeasured correlations among those households in the same location. Across all variables, we have the following hypotheses:

$$H_0: \beta_j = 0 \qquad H_1: \beta_j \neq 0$$

The variables included in X_i are listed in Table 6. It is important to note that the values for these variables are self-reported for each household and therefore subjective.

While it could be useful to have third party verified data, particularly for the agricultural variables, for the purposes of this study the subjective values are preferred. This is because a household's rationing status is based on a subjective view of the world, this is especially true of the risk rationed as they are concerned with their perceived risk of collateral loss. This is not necessarily equal to their actual risk of collateral loss.

Variable	Description
Age	The age of the head of household
Education	Highest level of education for head of household
Female	Binary variable =1 if head of household is female
Household Adults	Number of adults living in household
Household Size	Number of people living in household
Total Acres	Total acres a household farms
Maize per Acre	Production of maize in rainy season per acre
Plots	Number of different plots farmed
Ownership	Percentage of plots farmed the household owns
Average Distance	Average distance from household to plots they farm
Productive	Subjective productive asset (animals used in agricultural production) value. Scaled by 10,000 for ease of interpretation
Livestock Income	Value of income from livestock sales over last 12 months. Scaled by 10,000 for ease of interpretation
Percent Food	The percentage of household expenses spent on food
Subjective Welfare	Subjective score on scale of 1-5 of economic standing
Risk Aversion	Outcome of risk game on scale of 1-5, 1 being risk averse, 5 being risk seeking

Table 6: Description of socioeconomic variables used in determinant analysis.

Next we move onto a description of the uptake analysis methods.

Uptake Analysis Methods

The uptake analysis is concerned with evaluating the effectiveness of the RCC product in inducing greater participation in the credit markets by the risk rationed and more generally any correlations between the various rationing groups and uptake of credit. In order to answer these questions we utilize (A) descriptive statistics of uptake across rationing groups, (B) descriptive statistics of uptake across product offerings, and (C) a logit regression to evaluate both ration status and product offered on uptake.

This last analysis is what we will spend our time explaining here. Before going into the regression characteristics though, the control group was dropped before any uptake analysis was conducted. This is because these households were not offered any credit access and their inclusion would bias results. The logit regression model is as follows:

$$Y_i = C + \beta_j{}' X_i + \gamma_j{}' A_i + \vartheta_j{}' Z_i + \varepsilon_i$$

Where Y_i is a binary variable stating whether household i accepted a loan, X_i is a vector of binary ration status variables, A_i is a vector of binary uptake variables for different credit products and Z_i is a vector of socioeconomic variables to absorb noise. β_j, γ_j, and ϑ_j are vectors of parameters associated with each variable classification. Similarly to the determinant analysis, standard errors are clustered at the location level and we also run the same model as an OLS as a robustness check. An important note here, we do not include the price rationed in or the normal credit offering in the regressions such that the results are relative to these groups. They are chosen because they represent (A) "normal" interactions with credit markets, and (B) "normal" credit products. This allows us to detect any effects that being credit rationed has on uptake of credit and any effects that being offered RCC had on uptake relative to a normal credit product. Across the three categories of variables, we have the following hypotheses:

$$H_0: \beta_j = 0 \qquad H_1: \beta_j \neq 0$$

$$H_0: \gamma_j = 0 \qquad H_1: \gamma \neq 0$$

$$H_0: \vartheta_j = 0 \qquad H_1: \vartheta_j \neq 0$$

For clarity the individual variables in each of the three categories of variables included in the regression can be found in table 7.

Category	Variables
X_i **Ration Status**	Risk Rationed
	Quantity Rationed
	Transaction Cost Rationed
A_i **Type of Credit Product Offered**	RCC
	RCC with 75% Subsidy
	RCC with 50% Subsidy
	RCC with 25% Subsidy
Z_i **Socioeconomic and Production Variables to Control Noise**	Age
	Education
	Female
	Household Adults
	Household Size
	Total Acres
	Productive Assets
	Percent of Income Spent on Food
	Subjective Welfare

Table 7: Variables used in the uptake analysis, broken into the three categories used in regression.

Additionally, beyond the regression analysis we also utilize contingency tables and calculate odds ratios to further explore the differences in uptake between normal credit and RCC credit products within the rationing groups. We now move on to our discussion of the results.

CHAPTER 4

RESULTS

Determinant Analysis Results

Following the empirical strategy found above, the coefficients from the multinomial logit, individual bivariate logits and individual bivariate OLS regression analyses tell a mostly consistent story. The regression results are reported in Tables 8, 9, and 10. For ease of understanding, in the discussion that follows we will mainly discuss the linear probability coefficients, noting the odds from the logit regression and results of multinomial logit when they are not in agreement with the linear probability coefficients – in terms of either significance or sign. These occasions are limited. We will also touch on the multinomial results when their potential story due to normalizing over the price rationed group is especially suggestive.

One shortfall of the linear probability model is that occasionally the predicted probabilities land outside the 0,1 theoretical range, however, since this analysis has an explanatory purpose instead of a predictive purpose we are comfortable with this limitation. The benefit of utilizing the linear probability model is that the coefficients can be interpreted as direct marginal effects (Verteramo Chiu et al., 2014). In addition to the tables reported below, we also run a multinomial logit with only three rationing groups (price, quantity, and risk rationed) as well as a logit where we combine the quantity rationed and risk rationed groups into a singular constrained group and have included these results in appendices 2 and 3. These results reach similar conclusions to those we report in detail here. We will now discuss the explanatory variable coefficients in turn with the various rationing groups.

Age is not significantly correlated with any of the rationing groups across the regressions. This suggests that there may not be learning over time that effects how a household interacts with the credit markets.

Education is significant at the .05 level for price rationing, suggesting that the more education the head of household has the more likely they are to interact with the credit markets in the expected way. Additionally, in the multinomial Logit, education is negatively associated with the risk rationed group at the 5% level. In the linear probability model, this significance is at 10.9% and in the bivariate logit it is at 10.5%. This suggests that those with less education are more likely to be risk averse and/or unable to understand the conditions surrounding potential loss of collateral.

Having a **female head of household** is negatively associated with being quantity rationed at the 5% confidence level. This could suggest that microfinance programs aimed at empowering women in Kenya are having their desired affect as women-led households are finding it easier to be approved for credit compared to men-led households.

While there was no significance in the linear probability models for the number of **household adults'** variable, in both of bivariate and multinomial Logit the more adults, the greater the association to the transaction cost rationed group. This could suggest entrenchment to the status quo and biased beliefs from earlier contact with less efficient microfinance lenders.

When looking at **household size** (population), price rationed is significantly and negatively associated at the 10% level in the bivariate logit model and just outside in the linear probability model ($p=0.118$). This may suggest that households with more people have greater survival costs and are less likely to be offered a loan or less willing to risk collateral. The first idea, that the greater the household size the less likely a household is to be offered a loan has further evidence in multinomial Logit

model where household size just misses significance at the 10% level for quantity rationed as compared to price rationed (p=0.102).

Next, looking at **total acres**, we see broad consensus across the models that the more acres a household farms the less likely they are to be risk and transaction cost rationed. This makes theoretical sense because of the decreasing marginal utility of farmland. The more farmland a household has, the less important collateralizing some land to secure a loan becomes.

Maize production per acre is insignificant across all models and all rationing statuses. This is interesting because theoretically, we would assume that those with the greatest yields would either (A) already be accessing the credit markets to finance improved technologies such as high-yielding seeds and fertilizers and therefore be price rationed, or (B) have self-financing capabilities due to greater market penetration and therefore also be price rationed.

The next variable, **number of plots**, also showed no significance across models and rationing statuses. The variable, number of plots, can be understood in two ways. It could be that the more plots a household farms, the greater their production capacity is. However, it could also be interpreted as the greater the number of plots, the less efficient the production operations are. We tend to believe that more plots signals inefficiency and this results combined with the results for the maize production per acre variable suggest that the interaction between production efficiency and credit rationing status could be a potentially interesting line of inquiry for future research.

Ownership of the land a household farms is negatively associated with a household being in the transaction cost group in both the logit and multivariate logit models at the 5% level. This may suggest that households with titles have more familiarity with paperwork, or having titles is required for the paperwork. This is another area where more study could be directed.

Average distance to farmland is insignificant across models and rationing statuses. This variable fits into the discussion of the relationship between agricultural production efficiency and credit rationing. The fact that there does not appear to be a relationship between a household's farming efficiency and their credit ration status is puzzling.

Moving onto **productive** assets, which is a subjective valuation of a household's productive livestock assets useful in agriculture, we find that it is negatively associated with the risk and quantity rationed groups across models. This is as expected because on the one hand, the fewer productive assets a household has, the more valuable those assets are to the household and the more risk averse they will be around loan agreements that involve collateralizing their assets. On the other hand, if a microfinance institution or rural agricultural bank sees that a household doesn't have the assets needed to collateralize a loan, they may not offer a contract, pushing the household toward the quantity rationed group. Secondarily, we find productive assets are positively associated with price and transaction cost rationed. This is as expected for the price rationed, as it is the flip side of the coin from the quantity and risk rationed theorization. That the transaction cost rationed are more likely to have more productive assets is a trickier result to explain and we will not hypothesize on the reasoning behind it as its not core to the analysis.

Livestock income is significantly, at the 1% level, and negatively associated with being in the transaction cost rationed group across the logit models, and positively associated at the 5% level with the price rationed group in the linear probability model. Taken together, these results suggest that the more income a household makes from the sale of livestock, the more likely they are to interact with the credit market as expected, possibly because of greater familiarity with market transactions.

Of particular interest in the context of risk contingent credit are the results for the **percentage of income spent of food** coefficient estimations. Across two of the three models this variable is significantly associated with the risk rationed group at the 10% level (logit p value =0.106). The greater the share of food in the household's budget, the more risk averse they act by not risking collateral in order to gain access to credit. They have tight budgets and this can result in a focus on safe, low-yielding production methods instead of high-growth methods and also increases the utility of their productive assets, which shifts their utility calculation resulting in zero effective demand even if they have notional demand for credit. This result suggests a consideration for other markets that risk contingent credit may be particularly well suited to serve.

Another especially important variable for risk contingent credit is the **subjective welfare** variable. In the regression results, the coefficient is significantly associated to the price rationed group (5% level), suggesting that the higher in society a household sees themselves being the more likely they interact with the credit markets as expected. Looking at the both the bivariate and multinomial Logits this story is confirmed with greater and more powerful evidence. In the multinomial Logit, the quantity, risk, and transaction cost rationed groups are all negatively associated with subjective welfare, meaning that relative to those who interact with the credit market as expected, those that view their society level as being lower are more likely to rationed.

Finally, the **risk aversion** variable is not significantly associated with any of the rationing groups. We believe that this is due to a poor proxy, especially in the view of other results with implications for risk averseness.

Multinomial Logit Results	(1)	(2)	(3)	(4)
VARIABLES	price	Quantity_rationed	Risk_rationed	transaction_cost
age		0.007	0.008	0.010
		(0.259)	(0.205)	(0.394)
education		-0.028	-0.056**	-0.042
		(0.280)	(0.043)	(0.352)
female		-0.425	0.198	0.212
		(0.168)	(0.282)	(0.652)
hh_adults		-0.164	-0.048	0.147*
		(0.243)	(0.516)	(0.097)
hh_size		0.134	0.060	0.041
		(0.102)	(0.286)	(0.554)
total_acres		-0.002	-0.041**	-0.088**
		(0.920)	(0.026)	(0.018)
maize_per_acre		-0.000	-0.000	-0.000
		(0.489)	(0.320)	(0.563)
plots		-0.112	0.063	0.164
		(0.322)	(0.449)	(0.244)
ownership		-0.295	-0.514	-1.392**
		(0.504)	(0.226)	(0.019)
ave_dist		-0.026	-0.127	-0.276
		(0.890)	(0.470)	(0.404)
productive		-0.027**	-0.019**	0.032**
		(0.029)	(0.033)	(0.015)
l_income		-0.002	-0.027	-0.285***
		(0.913)	(0.396)	(0.000)
percent_food		-0.660	0.428*	0.397
		(0.390)	(0.088)	(0.711)
sub_welfare		-0.423**	-0.202*	-0.554***
		(0.029)	(0.059)	(0.010)
ra		0.032	-0.023	-0.050
		(0.733)	(0.611)	(0.483)
Constant		0.577	1.011	-0.077
		(0.652)	(0.114)	(0.960)
Observations	1,144	1,144	1,144	1,144
Robust pval in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Table 8: Results from the determinant analysis via a multinomial logit regression.

Logit Results				
VARIABLES	price	quantity	risk	trans
age	-0.007	0.003	0.005	0.006
	(0.168)	(0.682)	(0.354)	(0.567)
education	0.050**	0.000	-0.047	-0.013
	(0.019)	(0.999)	(0.105)	(0.780)
female	-0.098	-0.549*	0.247	0.145
	(0.559)	(0.064)	(0.155)	(0.764)
hh_adults	0.049	-0.149	-0.031	0.186**
	(0.366)	(0.323)	(0.710)	(0.042)
hh_size	-0.071*	0.105	0.030	0.004
	(0.082)	(0.266)	(0.592)	(0.958)
total_acres	0.031	0.006	-0.035*	-0.090**
	(0.108)	(0.573)	(0.055)	(0.012)
maize_per_acre	0.000	-0.000	-0.000	-0.000
	(0.268)	(0.578)	(0.548)	(0.667)
plots	-0.033	-0.137	0.069	0.150
	(0.692)	(0.195)	(0.340)	(0.216)
ownership	0.577	0.049	-0.305	-1.102**
	(0.142)	(0.912)	(0.387)	(0.021)
ave_dist	0.120	0.041	-0.098	-0.206
	(0.480)	(0.804)	(0.487)	(0.469)
productive	0.014	-0.020*	-0.018**	0.038***
	(0.138)	(0.071)	(0.025)	(0.002)
l_income	0.034	0.006	-0.019	-0.263***
	(0.161)	(0.696)	(0.547)	(0.000)
percent_food	-0.234	-0.900	0.495	0.216
	(0.408)	(0.227)	(0.106)	(0.834)
sub_welfare	0.278**	-0.287	-0.065	-0.388**
	(0.016)	(0.105)	(0.404)	(0.031)
ra	0.014	0.044	-0.025	-0.048
	(0.758)	(0.615)	(0.552)	(0.484)
Constant	-1.621**	-0.782	0.124	-1.612
	(0.027)	(0.499)	(0.787)	(0.228)
Observations	1,144	1,144	1,144	1,144
Robust pval in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Table 9: Results from individual logit regressions for each rationing status.

Regression Results				
VARIABLES	price	quantity	risk	trans
age	-0.001	0.000	0.001	0.000
	(0.274)	(0.788)	(0.493)	(0.482)
education	0.012**	-0.000	-0.011	-0.001
	(0.028)	(0.950)	(0.116)	(0.702)
female	-0.028	-0.045*	0.064	0.009
	(0.487)	(0.069)	(0.154)	(0.711)
hh_adults	0.011	-0.013	-0.006	0.009
	(0.393)	(0.346)	(0.741)	(0.141)
hh_size	-0.015	0.009	0.005	0.001
	(0.118)	(0.319)	(0.678)	(0.836)
total_acres	0.003	0.001	-0.003*	-0.001
	(0.115)	(0.592)	(0.062)	(0.297)
maize_per_acre	0.000	-0.000	-0.000	-0.000
	(0.327)	(0.546)	(0.659)	(0.684)
plots	-0.006	-0.011	0.014	0.003
	(0.748)	(0.183)	(0.333)	(0.554)
ownership	0.140	0.004	-0.079	-0.065
	(0.147)	(0.914)	(0.342)	(0.233)
ave_dist	0.031	0.002	-0.025	-0.008
	(0.446)	(0.886)	(0.438)	(0.514)
productive	0.003**	-0.001	-0.003**	0.001
	(0.035)	(0.171)	(0.020)	(0.311)
l_income	0.004**	0.000	-0.002	-0.002
	(0.014)	(0.875)	(0.280)	(0.135)
percent_food	-0.078	-0.076	0.138*	0.017
	(0.247)	(0.272)	(0.076)	(0.752)
sub_welfare	0.067**	-0.028	-0.020	-0.019
	(0.028)	(0.106)	(0.272)	(0.202)
ra	0.002	0.004	-0.005	-0.002
	(0.823)	(0.622)	(0.619)	(0.526)
Constant	0.115	0.233*	0.532***	0.120
	(0.502)	(0.051)	(0.000)	(0.163)
Observations	1,144	1,144	1,144	1,144
R-squared	0.059	0.013	0.041	0.016
Robust pval in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Table 10: Results from individual OLS regressions for each rationing status.

Uptake Analysis Results

We now move onto the results of the uptake analysis. First, we will go over some descriptive statistics and then analyze the regression results. Over the course of the RCT, Equity Bank distributed loans to 266 households. Figure 5 shows loan acceptance by ration status. Unsurprisingly, the price rationed were most likely to accept a loan, with 35.6% acceptance rate. The quantity rationed had a 34.1% acceptance rate, then the risk rationed had 30.4% and the transaction cost rationed had a 16.2% acceptance rate, but with a much smaller base. Table 11 shows the acceptance rate across the credit products that were offered in the RCT. The standard RCC product had a higher acceptance rate than the traditional credit, and interestingly the greater the subsidy on the RCC, the lower the acceptance rate. The effects of the subsidy on usage of credit, and livelihood outcomes could be an area for more exploration. One interpretation of the lack a positive effect of subsidies on uptake of credit, could be that the study population has highly inelastic demand for credit and they are not price sensitive when it comes to agricultural loans.

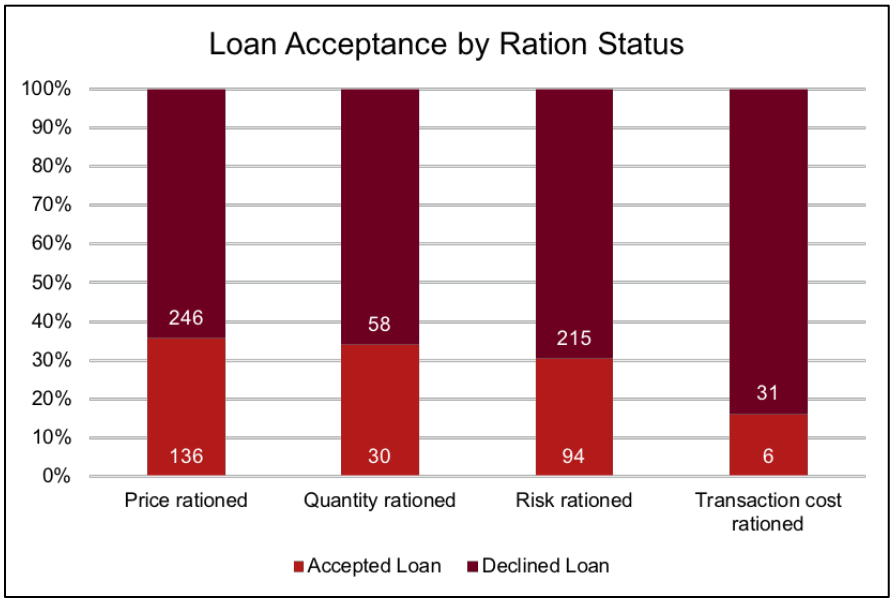

Figure 5: Breakdown of loan acceptance by ration status.

	Accepted	Declined	Percentage Accepted
Normal credit	107	243	31%
RCC	123	227	35%
RCC 25% subsidy	15	25	38%
RCC 50% subsidy	12	24	33%
RCC 75% subside	9	30	23%

Table 11: Breakdown of loan acceptance by type of credit product offered.

Turning our attention now to the regression analysis described in the empirical strategy section, we find some puzzling results. The regression results are located in Table 12, and we report on both the logit and OLS coefficients. For robustness, we also run the regressions with only those offered regular credit and with only those offered an RCC product. These results can be found in appendices 4 and 5, but we will pass on discussing them in detail as they corroborate the same story as the other regressions. As we look over the results, it's important to remember that they are normalized over the price rationed for the rationing groups, and normal credit offered.

Surprisingly, the regression does not show any significant correlation between whether a household chose to accept credit and both (A) being either risk or quantity rationed and (B) the type of RCC they were offered. While being transaction cost rationed is negatively associated with credit uptake at the 1% level, there are so few of the transaction cost rationed in our study pool that it could skew the results. None of the types of RCC are statistically significantly correlated with uptake, however, it is still worth noting that RCC with a 75% subsidy was negatively associated with uptake while the others were positive. The only other variable that is significantly associated

is the maize per acre variable at the 5% level. This means that those who are most efficient at production are also those who are more likely to use credit.

VARIABLES	Logit	OLS
risk	-0.161	-0.035
	(0.511)	(0.515)
quantity	-0.020	-0.006
	(0.934)	(0.916)
trans	-1.032***	-0.181**
	(0.005)	(0.012)
rcc	0.262	0.055
	(0.194)	(0.233)
rcc75	-0.351	-0.065
	(0.434)	(0.430)
rcc50	0.229	0.048
	(0.548)	(0.573)
rcc25	0.416	0.087
	(0.177)	(0.250)
age	-0.004	-0.001
	(0.583)	(0.587)
education	0.012	0.003
	(0.719)	(0.737)
female	-0.199	-0.039
	(0.315)	(0.344)
hh_adults	0.065	0.014
	(0.410)	(0.433)
hh_size	-0.022	-0.005
	(0.573)	(0.573)
total_acres	-0.013	-0.002*
	(0.227)	(0.079)
maize_per_acre	0.001**	0.000*
	(0.030)	(0.057)
productive	0.004	0.001
	(0.484)	(0.553)
percent_food	-0.564	-0.115
	(0.151)	(0.181)
sub_welfare	0.090	0.017
	(0.427)	(0.475)
Constant	-0.798	0.315*
	(0.302)	(0.081)
Observations	816	816
Robust pval in parentheses *** p<0.01, ** p<0.05, * p<0.1		

Table 12: Logit and OLS regression output from uptake analysis.

We also look into the odds ratios for the price, quantity and risk rationed groups to see if there is a difference in uptake between those who are offered normal credit and those who are offered one of the RCC products. To do this, we pool the standard RCC product and the subsidized products into one group and then create contingency tables (Tables 13, 14, 15) that compare the credit products on the vertical axis and the uptake across the top axis for each of the rationing groups. Then from the results of the contingency tables we are able to calculate the odds ratios for each group using the following formula: Odds ratio: $\theta = (n_{11} * n_{22}) / (n_{12} * n_{21})$. For each of the rationing groups the odds ratios tell us that:

- Among risk rationed households, the odds of declining the credit offer for those offered normal credit was 1.24 times the odds for those offered RCC.
- Among quantity rationed households, the odds of declining the credit offer for those offered normal credit was .92 times the odds for those offered RCC.
- Among price rationed households, the odds of declining the credit offer for those offered normal credit was 1.27 times the odds for those offered RCC.

Risk Rationed		Uptake		
		Declined	Accepted	Total
Credit Product	Normal Credit	96	37	133
	RCC Credit	119	57	176
	Total	215	94	309

Table 13: Contingency Table for the risk rationed group.

Quantity Rationed		Uptake		
		Declined	Accepted	Total
Credit Product	Normal Credit	24	13	37
	RCC Credit	34	17	51
	Total	58	30	88

Table 14: Contingency Table for the quantity rationed group.

Price Rationed		Uptake		
		Declined	Accepted	Total
Credit Product	Normal Credit	112	54	166
	RCC Credit	134	82	216
	Total	246	136	382

Table 15: Contingency Table for the price rationed group.

The analysis shows inconclusive evidence of increased uptake of credit due to households being offered RCC as compared to regular credit. However, the lack of significance for the risk rationing and quantity rationing variables means that these households were acting in a similar manner as the price rationed. One interpretation is that the intervention successfully moved the quantity rationed and risk rationed onto the demand curve, but that the type of credit product offered did not have an effect on uptake of loan. Combined with results saying that the subsidy did not have an effect on uptake, there would appear to be pent up, and inelastic, demand across all of the rationing groups for agricultural credit. This highlights the importance of extending agricultural financial markets in developing countries, regardless of the form it takes.

This result is not to suggest that RCC is not a needed advancement in agricultural finance in developing countries, but it does suggest a deeper look into credit rationing groups to better understand any differences in how they interact with credit markets. It will also be good to continue testing RCC in similar parts of Kenya in order to have a better sense of the effects of RCC over time. Would there be a difference in demand in years following payouts from the insurance? It will be interesting to see what additional insights the follow-up survey will tell us about how the consumers view RCC, particularly because of the presence of basis risk that the trial experienced, which will be discussed in greater detail in the next chapter.

CHAPTER 5

DISCUSSION

We have just reviewed the results of the two analyses that were conducted in order to gained a better understanding of whether or not there are key determinants that are significantly correlated with a household ending up in any of the four rationing groups and the effect that a household being in these rationing groups and the type of credit product they were offered had on their likelihood of accepting a loan. These analyses were based on data collected in the Machakos region of Kenya as part of the SATISFy project, which is an RCT to evaluate the potential of RCC to open access to credit markets for households who may not have entered credit markets before due to the risk of collateral loss.

First, we will discuss the results of the determinant analysis. It can be said that the most interesting take away from the determinant analysis is how uninteresting the results are. There are few variables that are significantly associated with a household being in one ration group over another, and when variables are significantly associated with a rationing group, the results confirm what intuition would suggest. For example, in the multinomial logit regression the higher a household's subjective welfare the more likely a household will be price rationed as compared to the other three rationing groups. With respect to the risk rationed, who are the target population for RCC, the greater the acreage and productive assets the less likely a household will be risk rationed, suggesting decreasing marginal utility of both these assets and greater

willingness to risk putting them up as collateral in a lending contract. Additionally, one other result from this analysis that deserves special attention is the fact that female headed households are less likely to be quantity rationed meaning that they are less likely to be locked out of credit markets due to supply-side constraints. This suggests that the MFIs with a mandate to lend to females are having their intended impact in this region of Kenya.

A few of the other results suggest areas for deeper analysis and study in the future. Particularly, the results with relation to the percentage of income spent on food variable, that the greater this percentage, the more likely a household is to be risk rationed can be used to analyze other markets to determine where RCC may be well-suited to increase access to credit markets. Additionally, the results suggest that there is not a link between agricultural production efficiency and how a household interacts with the credit markets. This is not immediately intuitive and one would expect there to be links between these two variables. Future research into this relationship will help us better understand the true nature of credit rationing and how it affects households' interactions with credit markets.

Moving on to the uptake analysis, the questions we were most interested in answering were: Are there material differences between the credit rationing groups and their interactions with the credit markets, and does being offered RCC increase likelihood of a household accepting a loan. In this intervention, there was no difference between the acceptance of credit for the price, quantity, and risk rationed. This means that the broad intervention, offering households access to credit, was successful in moving the risk and quantity rationed onto the demand curve, where they

acted in a similar manner to the price rationed. One question this raises is whether there is actually a difference between the ration groups in how they interact with credit markets or whether these divisions are artificial and merely academic curiosities. This is an area where deeper research should be conducted.

The prior result, combined with the fact that the varying levels of subsidy on the RCC product had no effect on uptake, suggests that there was pent up and inelastic demand for credit among the study population. Since this was the first time that many of the households had access to a loan, it may not be surprising to have found that no matter their ration status, they were interested in accessing the loan in an attempt to increase their agricultural productivity and therefore welfare. This makes interpreting the fact that being offered RCC did not lead to greater uptake as compared to when households were offered a normal credit product more difficult. It is obvious though, that there is a need to expand access to credit for agricultural households in developing countries.

On this front, there is good news as an increasing number of firms are looking to extend these services. For example, the Initiative for Smallholder Finance, and the organizations in the Propagate Coalition are actively developing funds and strategies to deliver both credit and insurance to smallholders in emerging markets. More work will need to be done to determine the optimal place in the agricultural finance value chain for insurance to be available, but as mentioned earlier, it is increasingly clear that insurance markets and credit markets need to be developed in unison for the greatest success in delivering services.

The RCT that delivered the data used in the above two analyses was well-developed and executed in good faith. However, that does not mean there were not challenges that arose through the process. We will now discuss these challenges and limitations quickly in order to give the reader an understanding of key lessons learned and to inform future studies into the efficacy of RCC.

First, while it was emphasized to the farmers during the pre-training for the RCT that they would not be receiving cash, rather a loan would be advanced to the local agro-dealer's account, many of the farmers still expected to get cash payments and some dropped out when it became clear to them that this was not the case. Another potential cause for concern is that the farmers who were randomly drawn to be in the control group, and therefore were not offered credit, may have attempted to influence their neighbors who were offered credit to not accept it in solidarity. There is evidence that some farmers in the control group expressed frustration and were attempting to exert influence on others to decline. In future experiments, the control group could be those who were only offered normal credit as compared to RCC. One last issue that arose in this RCT was that the project started later than expected and therefore left little turnaround time between when credit offers were extended and optimal planting time, meaning that the production cycle may have been affected for some farmers.

Another consideration for future experiments examining RCC is to have a larger pool of randomly drawn households receive the subsidies. In this experiment this pool of participants were much smaller than those being offered fairly priced RCC and normal loans. With equal groups across RCC, subsidized RCC, and normal credit

it is possible that greater insights into the (in)effectiveness of the subsidy could be generated.

Finally, as mentioned earlier, basis risk ended up being an issue with the RCC due to the index being a simple cumulative rainfall measure. During the crop cycle during which the RCT took place, initial forecasts were very positive for the harvest with many farmers expecting a bumper crop. However, the rainfall dried up at the wrong time for plant growth and while the cumulative rainfall was above the trigger point across the Machakos region, many farmers experienced significant losses. This could reduce farmer trust in RCC and by extension Equity Bank and should another trial in Machakos be conducted it may be met with wariness. Due to this concern, and because the team knew about the potential for basis risk associated with a simple cumulative rainfall index, they will be assisting farmers with their repayments in order to keep a positive image of both the product and Equity Bank.

As the team looks to develop the next trials, there will be an updated index that will reduce the potential for basis risk by not only accounting for the cumulative rainfall, but also considering the frequency and the alignment with the crop growth cycle. There is still much empirical work to be done to better understand the potential of RCC to open access to credit markets for smallholder farmers and it will be interesting to see the outcome of the next trials that use this more sophisticated form of index insurance. Looking even farther out beyond the next round of trials for RCC, it will also be interesting to see if integrating RCC into a mobile money platform such as M-PESA in Kenya (which has captured a lion's share of the market) would increase

both farmer interest/trust in the product and also reduce transaction costs and time delays.

It is still early days for integrated credit and insurance solutions for smallholder agricultural households in Kenya and beyond. With the recognition that credit and insurance markets will need to be developed together to boost the livelihood outcomes of the targeted populations, research should continue to be conducted into these products as well as research into the optimal point in the value chain for the insurance to be offered.

CHAPTER 6

CONCLUSION

There is a global shift underway to increase access to services for those at the base of the economic pyramid. A growing class of entrepreneurs, impact investors, foundations and development finance institutions are focused on figuring out ways to boost the outcomes for those at the base of the economic pyramid while also generating a positive financial return. Since many of the world's poorest households live in rural areas and are reliant on agriculture not just for their limited income but also for subsistence, there is a need to develop financial products that can effectively be delivered to increase agricultural productivity while not overloading households with risk.

This paper reported on research done into RCC, a novel financial product that links index insurance to microfinance loans. This research was conducted through an RCT as a part of the SATISFy project administered by IFPRI and Equity Bank in Kenya. This research adds to the growing literature that not only considers credit constraints that come from the supply side, but also on the constraints that come from the demand side. The results suggest that we need to have a better understanding of the credit rationing statuses: price, quantity, risk, and transaction cost rationed. Do these categories accurately represent how agricultural households interact with credit markets? Also, the results suggest that more work needs to be conducted in order to

understand RCC's potential in opening up access to credit markets and the impact that RCC has on farmer productivity and welfare.

RCC is an exciting development in the drive to extend financial services to those at the base of the economic pyramid and its development is happening against the backdrop of an increasing recognition and desire of the international community to use the wide expanse of financial tools to generate not only financial returns, but also to create positive social and environmental impact as we look to develop the sustainable economy of the future and increase opportunities for those traditionally left behind.

APPENDIX

Appendix 1

The following pages contain the survey instrument used to collect the baseline information for the SATISFy RCT in the Machakos region of Kenya during the late spring/early summer of 2017.

SATISFY PROJECT BASELINE HOUSEHOLD SURVEY
MACHAKOS COUNTY KENYA
MARCH 2017
IFPRI. CORNELL. AGRI-FOOD

A:	Basic household information
B:	Household member education and health
C:	Agricultural land
D:	Crop production
E:	Crop inputs (fertilizer)
F:	Crop inputs (labor)
G:	Crop inputs (seeds)
H:	Livestock ownership
I:	Agricultural shocks
J:	Food consumption
K:	Non-food expenditure
L:	Subjective welfare and food security
M:	Credit rationing
N:	Risk preference

SATISFy Project Baseline Evaluation Survey - 2017

CONSENT FORM

Hello! My name is ____ . First of all I would like to thank you for taking the time to meet with us. I work for Agri-Food Economics Africa-Kenya and represent a research project called Satellite Technologies, Innovative and Smart Financing for Food Security (SATISFy). This project aims to build resilience and increase agricultural productivity by innovative financing. As part of the project, we would like to gather information from selected households in Machakos and your household is one of the 1150 households selected to be interviewed now and at the end of the project (after one years). Data collected from study households like yours will be used to understand major constraints and opportunities for improving agricultural productivity and livelihoods. Analysis of baseline and follow-up data will allow the research team to assess the effect of the project help identify successful innovation for building resilience.

Data to be collected from you will be coded and will be kept strictly confidential. All household identifying information will be held in strict confidence and used only for research purposes. No identifying information (e.g., respondent name) will appear in data report. Participation in this interview is voluntary and you may refuse to participate, discontinue the interview at any time, or skip any question you do not want to answer with no penalty or loss of benefits to which you are otherwise entitled. You are allowed to ask questions concerning the research, both before agreeing to participate in the interview, during, and after the interview.

As head of the household or spouse of the head, I would like to ask you questions mainly about agricultural activities, consumption and subjective welfare. Answering these questions is expected to take around 2 hours. You may find some of the questions (for example about household asset ownership and consumption of food and non-food items) sensitive and you can refuse to answer any sensitive question without any consequence whatsoever.

Please contact Apurba Shee at +255272553051 (or a.shee@cgiar.org) or Simon Kimenju at +254722425807 (or skimenju@gmail.com) if you have questions about the research and if you face injury as a result of your participation in this survey. Please contact the chair of the International Food Policy Research Institute Institutional Review Board at ifpri-irb@cgiar.org if you need more information or have questions about this study.

Before I start, do you have any questions or is there anything I have said on which you would like further clarification?

May we proceed with the interview?

Subject Name Subject Signature

Consent form approved by IFPRI IRB on _____

Household location

A1	A2	A3	A4	A5
Division	Location	Sublocation	Village	Household
				Enter 4-digit household code from the list of sampled households**

See codes

GPS coordinates

			Degree	Minute	Second
A6	GPS Latitude	S			
A7	GPS Longitude	E			
A8	Elevation (in meters)				

Survey Staff Details

A9	ENUMERATOR NAME:	
A10	DATE OF INTERVIEW:	/ /
A11	NAME OF SUPERVISOR:	

Household information

A12	Name of head of household	
A13	What is the name of the respondent if not head?	
A14	Was translator used? 1. Yes 2. No	

Mar 2017 Version

COVER PAGE CODES

Division codes	
Code	**Division name**
1	Matungulu
2	Kangundo
3	Kathiani
4	Mwala
5	Yatta

Location codes	
Code	**Location name**
11	Uamani
12	Kiboko
13	Kayata
14	Kyanzavi
21	Tala
22	Matungulu
23	Kanzalu
24	Kakuyuni
31	Kathiani
32	Mitaboni
33	Iveti
41	Mwala
42	Mbiuni
43	Masii
51	Kithimani
52	Matuu

Sublocation codes	
Code	**Sub-location name**

Village codes	
Code	**Village name**

Enumerator codes	
Code	**Name**

Supervisor codes	
Code	Name

SECTION B. HOUSEHOLD* MEMBERS and EDUCATION

INDIVIDUAL ID	RESPONDENTS CAN ANSWER THESE QUESTIONS						ASK THESE QUESTIONS ONLY FOR MEMBERS 7 YEARS OR OLDER		ASK MEMBERS 14 YEARS OR OLDER			
	Please tell me the names of all members of the household starting with the head of household: **LIST ONLY NAMES OF HOUSEHOLD MEMBERS**	What is the relationship of [NAME] to the head of household? 1 Head 2 Spouse 3 Son/daughter 4 Son/daughter in law 5 Grandchild 6 Parent or parent in law 7 Other relative (male or female) 8 Other (not related)	Is [NAME] male or female? 1 Male 2 Female	How old is [NAME]? **IF 7 YEARS OR OVER, GIVE YEARS ONLY. IF LESS THAN 7 YEARS, GIVE YEARS AND MONTHS.** Years / Months (Only for those below 7 years) **IF AGE IS LESS THAN 7 YEARS ► NEXT LINE**		How many months of the past 12 months has [NAME] lived with the household?	What is the highest grade of education completed by [NAME]? Write 0 for nursery or no education. For standards 1 to 8, write grade number. For forms 1-6 write 9-14. For higher studies enter: 15 Diploma/Certificates 16 Degree 17 Postgraduate 97 Other (specify)	What is the primary activity of [NAME]? 1 Crop production 2 Livestock 3 Non-farm employee 4 Farm employee 5 Self employed 6 Student 7 Unpaid housework 8 Looking for work -95 None	What is [NAME]'s marital status? 1 Monogamous married 2 Polygamous married 3 Living together 4 Separated 5 Divorced 6 Never married 7 Widow(er)	**During the last 12 months**, how many days was [NAME] unable to work as a result of his/her illness?	What type of illness, symptoms or injury caused [NAME] to be unable to work? **SELECT UP TO TWO** 1 FEVER 2 MALARIA 3 STOMACH ACHE/DIARRHEA 4 HEADACHE 5 HEART 6 LUNG 7 MATERNITY 8 ULCER 9 INJURIES / WOUNDS (E.G., FROM ACCIDENTS) 10 CANCER (NOT RELATED TO HEART / LUNG) -96 OTHER	
											1ST	2ND
ID	B1	B2	B3	B4a	B4b	B5	B6	B7	B8	B9	B10a	B10b
1												
2												
3												
4												
5												

* The household is defined as a group of people who share expenses and live and eat together most of the time.

SECTION C AGRICULTURAL LAND

NOTE: Plots of land rented out or in should be considered as separate parcels.

INTERVIEWER: ASK ABOUT PARCELS OF LAND ACCESSED BY THE HOUSEHOLD DURING MAR 2016 - MAR 2017, WHETHER OWNED BY THE HOUSEHOLD OR NOT

Parcel id number	How large is the land area of [PARCEL] that you accessed? NOTE: Plots of land rented out or in should be considered as separate parcels.	Does this parcel belong to your household? 1 Yes 2 No, we rent it from others ►C4 3 No, we sharecrop in ►C5 4 No, we borrow at no cost ►C5	Did your household **farm** this parcel during Mar 2016 - Mar 2017?	How did your household use this land during Mar 2016 - Mar 2017?	What is the type of the soil on this parcel?	What is the color of the soil of this parcel?	What is the slope of this parcel?	How long does it take to get to [PARCEL] from your house by the usual mode of transport (**one way in minutes**)
			1 Yes 2 No, left fallow ►C6 3 No, we rent it out to others 4 No, we share-crop it out 5 No, borrowed it out	1 Annual crops 2 Seasonal crops 3 Perennial crops 4 Livestock 5 Wood lots 6 Multiple uses -96 Other	1 Clay 2 Loam 3 Sand 4 Sand/loam 5 Silt -96 Other	1 Black 2 Brown 3 Red 4 Red/Brown 5 Grey/Brown 6 Grey	1 Flat 2 Steep terraced 3 Moderate slope 4 Steep slope 5 Depression	1 Adjacent to homestead 2 Less than 15 mins 3 15 -30 mins 4 31 - 60 mins 5 More than 1 hour
	Area in ACRE							

ID	C2	C3	C4	C5	C6	C7	C8	C9
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Crops

11	Maize
12	Beans
13	Cow peas

Quantity Units

Quantity unit codes*	
Code	**Unit**
1	Kilogram
2	Gram
3	Liter
4	Unit or Piece
5	Ngorongoro (2kg)
6	Maxibag (90kg)
7	Minibag (50kg)
8	25kg bag
9	10kg bag
10	Bale
11	Ox-cart
12	Canter
13	Wheelbarrow
-96	Other

***** Conversions for Maize:**

1 wheel barrow = 30kg	1 debe = 18 kg
1 ox cart = 150kg	1 gorogoro = 2.25kg
1 pickup = 1,500 kg	1 canter = 3,000kg

7

SECTION D CROP PRODUCTION

INTERVIEWER: NOTE THAT THE INFORMATION TO BE COLLECTED IN THIS MODULE IS AT THE CROP LEVEL. 1 SHORT SEASON: MAR 2016- JUL 2016, 2 LONG SEASON: OCT 2016-MAR 2017

ADD A NEW ROW FOR EACH CROP GROWN IN EACH PLOT.

SEASON ID	Crop code [SEE CODE PAGE ABOVE]	Was this an improved variety of [CROP]?	What was the area planted with [CROP] ?	In this area how many crops intercropped	How much [CROP] was harvested during the season?		Which family member had main responsibility for farming this crop?	How was the yield of your harvest in this season compared with harvest your household collects in a normal year?	What is the main reason for this difference in yield compared with yield the normal year?
	Crop code [SEE CODE PAGE ABOVE]	1 Yes 2 No -99 Don't know	Area in ACRE	Number	Quantity	Unit [SEE CODE PAGE]	1 Head 2 Spouse of head 3 Both head and spouse -96 Other	1 Much higher 2 Little higher 3 Roughly the same ►NEXT LINE 4 Little lower 5 Much lower 6 First harvest year ►NEXT SECTION -99 Don't know►NEXT LINE	1 Good rainfall 2 Bad rain fall 3 Fertilizer use 4 Improved seed use 5 Other chemical 6 Soil degradation 7 Pests or disease
D_1	**D_2**	**D_3**	**D_4a**	**D_4b**	**D_5a**	**D_5b**	**D_6**	**D_7**	**D_8**
1 Short season Mar 2016- Jul 2016									
2 Long season Oct 2016- Mar 2017									

SECTION E CROP INPUTS (FERTILIZER)

INTERVIEWER: COMPLETE INPUT DETAILS FOR EACH CULTIVATED CROP DURING SHORT AND LONG SEASON

SEASON ID	Crop codes					
		Which type of fertilizers did you use? 1 Urea 2 NPK 3 DAP 4 Super D 5 CAN -96 Other 6 A combination 7 None ► NEXT CROP	How much fertilizer was used? IF A COMBINATION OF FERTILIZERS IS USED, **QUANTITY** AND **VALUE** SHOULD REFER TO THE QUANTITY AND VALUE OF **ALL** THE FERTILIZERS USED			What percentage of the value of fertilizers used was subsidized? 0 No subsidy 1 Less than 25% 2 25%-50% 3 50%-75% 4 75%-100% -99 Don't Know
1 Short season Mar 2016- Jul 2016 2 Long season Oct 2016- Mar 2017	**[SEE CODE PAGE ABOVE]**		Quantity	Unit [SEE CODE PAGE]	Value **in KSH**	
E_1	**E_2**	**E_3**	**E_4a**	**E_4b**	**E_4c**	**E_5**
1 Short season Mar 2016- Jul 2016						
2 Long season Oct 2016- Mar 2017						

SECTION F CROP INPUTS (LABOR)

INTERVIEWER: ASK ALL QUESTIONS FOR EACH CULTIVATED CROP. PUT 0 IF NO LABOR IS USED FOR [ACTIVITY] FOR [CROP]

SEASON ID	Crop codes	For the [CROP] grown, how many **person-days*** of FAMILY, HIRED AND EXCHANGE LABOR were used on each of the following activities during long and short season?						Programmer: the sum of these percentage should be 100%		
1 Short season Mar 2016- Jul 2016 2 Long season Oct 2016- Mar 2017	**[COPY CROP CODES FROM CROP FLAP]**	Land preparation (including harrowing and ridging)	Planting	Fertilizing	Weeding, applying pesticides/herbicides	Harvesting	Other	How much of this labor was family labor? 0 0% 1 1-25% 2 26-50% 3 51-75% 4 76-99% 5 100%	How much of this labor was exchange labor? 0 0% 1 1-25% 2 26-50% 3 51-75% 4 76-99% 5 100%	How much of this labor was hired labor? 0 0% 1 1-25% 2 26-50% 3 51-75% 4 76-99% 5 100%
		Person days	Person days	Person days	Person days	Person days	Person days	Percent	Percent	Percent
F_1	**F_2**	**F_3a**	**F_3b**	**F_3c**	**F_3d**	**F_3e**	**F_3f**	**F_4**	**F_5**	**F_6**
1 Short season Mar 2016- Jul 2016										
2 Long season Oct 2016- Mar 2017										

*A person-day is the number of people working times the number of days worked. Example: 3 people working for 4 days is 12 person-days.

** Count assistance from other farmers through labor exchange as "Hired labor". Do not include labor provided by the household to **other farms**.

SECTION G CROP INPUTS (SEEDS)

INTERVIEWER: ASK Crop details FOR EACH CROP GROWN DURING MAR 2016-MAR 2017.

Season id	Crop code	Did your household grow [CROP] during Mar 2016 - Mar 2017 season?OR LONG OR SHORT? 1 Yes 2 No ►NEXT LINE	How much seed (in Kg) was used	How much of the seed you used during the season was saved from previous harvest? 1 All 2 Some 3 None	(ASK THIS IF G_5=1 OR 2) How many years ago did you purchase seeds for [CROP]? 1 2 years ago 2 3 years ago 3 More than 3 years ago 4 Never	ASK THESE QUESTIONS ONLY IF G_5=2 0R 3			
						Where did you obtain the seed that was purchased in this season? 1 Farmer 2 Grain traders 3 Input dealer 4 Cooperative 5 Extension service 6 NGO 7 Research institute 8 Seed company 9 Multiple sources -96 Other	Which varieties of seeds were purchased? 1. Hybrid seeds 2. OPV seeds 3. Local seed 3. Any combination	How did you pay for this seed? 1 Cash 2 Credit 3 Partial subsidy 4 Labor exchange 5 A combination -96 Other	How many minutes does it take to get to this supplier using the usual mode of transport? (one way in minutes) PUT - 98 if G_7 = 9
G_1	**G_2**	**G_3**	**G_4**	**G_5**	**G_6**	**G_7**	**G_8**	**G_9**	**G_10**
1 Short season Mar 2016- Jul 2016									
2 Long season Oct 2016- Mar 2017									

SECTION H LIVESTOCK OWNERSHIP

ASK THE HOUSEHOLD HEAD OR OTHER KNOWLEDGEABLE MEMBER

Code	Animal type	In the past 12 months, have members of your household raised or produced [ANIMAL TYPE]?	What type of management system does the household use for [ANIMAL TYPE]?	Which family member had main responsibility for taking care of the [ANIMAL TYPE]?	How many [ANIMAL TYPE] does your household currently own? For chickens, exclude chicks.	What is the estimated total value of [ANIMAL TYPE] your household currently own?	**Over the past 12 months**, how much have you earned in total from the following activities...?	
		1. Yes 2. No ►NEXT LINE IF RESPONDENT DOES NOT HAVE ANY OF THE ANIMAL TYPES LISTED ►SECTION I	1 Grazing/open air only 2 Intensive/Caging only 3 Mixed -98 Not applicable	1 Head 2 Spouse of head 3 Both head and spouse -96 Other	Number	KSH total	Activity	KSH total
H_1	**H_2**	**H_3**	**H_4**	**H_5**	**H_6**	**H_7**	**H_14a**	**H_14b**
100	Draught cattle						Rental/Hides	
101	Bulls -local-						Rental/Hides	
102	Bulls -improved-						Rental/Hides	
103	Fattening cattle -local-						Meat products	
104	Fattening cattle -improved-						Meat products	
105	Cows -local-						Dairy products	
106	Cows -improved-						Dairy products	
107	Heifers -local-							
108	Heifers -improved-							
109	Calves -local-							
110	Calves -improved-							
111	Horse/donkey/mule						Rental	
112	Goats -local-						Goat milk	
113	Goats -improved-						Goat milk	
114	Sheep						Wool/skins	
115	Pigs							
116	Chickens						Egg sales	
117	Fish							
118	Honey bees*							
119	Rabbit				*		Honey sales	

* Note: For honey bees, record number of occupied hives (not bees) in H_6, H_8, H_9, H_10; total value of hives in H_7; and value per hice in H_11.

SECTION I AGRICULTURAL SHOCKS

ENUMERATOR: ASK THE HOUSEHOLD HEAD OR THE MOST KNOWLEDGEABLE HOUSEHOLD M

SHOCK ID		Over the past **ten** years, was your household's welfare status severely affected negatively by any of the following events? 1 YES 2 NO ▶NEXT ITEM	Rank the three most significant shocks you experienced 1 MOST SEVERE 2 SECOND MOST SEVERE 3 THIRD MOST SEVERE
ID	**I1**	**I2**	**I3**
101	Drought		
102	Strong winds/storms		
103	Crop pests		
104	Livestock disease, died or stolen		
105	Household business failure, non-agricultural		
106	Loss of salaried employment or non-payment of salary		
107	Large fall in sale prices for crops		
108	Large rise in price of food		
109	Large rise in agricultural input prices		
110	Severe water shortage		
111	Loss of land		
112	Chronic/severe illness or accident of household member		
113	Death of a member of household		
114	Death of other family member		
115	Break-up of the household		
116	Jailed		
117	Fire		
118	Hijacking/robbery/burglary/assault		
119	Floods		
120	Immediate needs of money and selling crop at lowest price		
121	Political, tribal, and farmers' livestock conflict		

SECTION J FOOD CONSUMPTION

INTERVIEWER: ASK THE HOUSEHOLD HEAD AND THE SPOUSE (TOGETHER AND AS APPROPRIATE).

NOTE: IF THE HOUSEHOLD HAS FASTED IN THE PAST 7 DAYS THEN ASK THE RESPONDENT TO REFER TO A TYPICAL WEEK WHEN ANSWERING THESE QUESTIONS.

ITEM CODE	Food item	Within the past 7 days, did members of this household consume [FOOD] within the household? 1 YES 2 NO ▶NEXT LINE	How much [ITEM] in total did your household consume in the past 7 days? QUANTITY	UNIT [SEE CODE PAGE]	How much [ITEM] came from purchases? IF NONE WRITE 0 FOR QUANTITY QUANTITY	UNIT [SEE CODE PAGE]	How much did you spend to purchase [ITEM] in total? THIS QUESTION REFERS TO THE QUANTITY SPECIFIED PREVIOUSLY KSH	How much [ITEM] came from own-production? IF NONE WRITE 0 FOR QUANTITY QUANTITY	UNIT [SEE CODE PAGE]	How much [ITEM] came from gifts and other sources? IF NONE WRITE 0 FOR QUANTITY QUANTITY	UNIT [SEE CODE PAGE]
ID	J1	J2	J3a	J3b	J4a	J4b	J5	J6a	J6b	J7a	J7b
Cereals and Cereal products											
0101	Rice (paddy)										
0102	Maize (green, cob)										
0103	Maize (grain)										
0104	Maize (flour)										
0105	Millet and sorghum (grain)										
0106	Millet and sorghum (flour)										
0107	Wheat flour										
0108	Bread										
0109	Buns and biscuits										
0110	Macaroni, spaghetti										
0111	Other cereal products										
Starches											
0201	Cassava fresh										
0203	Cassava flour										
0204	Sweet potatoes										
0205	Arrow roots										
0206	Yams/cocoyams										
0207	Irish/round potatoes										
0208	Cooking bananas, plantains										
0209	Other starches										
Sugar and Sweets											
0301	Sugar										
0302	Sugarcane										
0303	Honey, syrups, jams, marmalade, jellies, canned fruits										
0399	Other sweets										

ITEM CODE	Food item	Within the past 7 days, did members of this household consume [FOOD] within the household? 1 YES 2 NO ▶NEXT LINE	How much [ITEM] in total did your household consume in the past 7 days? QUANTITY	UNIT [SEE CODE PAGE]	How much [ITEM] came from purchases? IF NONE WRITE 0 FOR QUANTITY QUANTITY	UNIT [SEE CODE PAGE]	How much did you spend to purchase [ITEM] in total? THIS QUESTION REFERS TO THE QUANTITY SPECIFIED PREVIOUSLY KSH	How much [ITEM] came from own-production? IF NONE WRITE 0 FOR QUANTITY QUANTITY	UNIT [SEE CODE PAGE]	How much [ITEM] came from gifts and other sources? IF NONE WRITE 0 FOR QUANTITY QUANTITY	UNIT [SEE CODE PAGE]
ID	J1	J2	J3a	J3b	J4a	J4b	J5	J6a	J6b	J7a	J7b
Pulses											
0401	Pigeon peas										
0402	Green grams										
0403	Cow peas										
0404	Beans										
0405	Other pulses										
Nuts and Seeds											
0501	Groundnuts in shell										
0502	Groundnuts (shelled)										
0503	Coconuts mature										
0504	Coconuts immature										
0505	Bambara nuts										
0506	Seeds and products from nuts/seeds (*excl.* cooking oil)										
0507	Wild nuts and seeds										
0508	Other nuts and seeds										
Vegetables											
0601	Onions										
0602	Tomatoes										
0603	Carrots										
0604	Green pepper										
0605	Spinach										
0606	Cabbage										
0607	Other green vegetables										
0608	Canned and dried vegetables										
0609	Wild vegetables										
0610	Other vegetables										
Fruits											
0701	Ripe bananas										
0702	Citrus fruits (oranges, lemon, tangerines, etc.)										
0703	Mangoes										
0704	Avocadoes										
0705	Water melon										
0706	Wild fruits										
0707	Other fruits										

ITEM CODE		Within the past 7 days, did members of this household consume [FOOD] within the household?	How much [ITEM] in total did your household consume in the past 7 days?		How much [ITEM] came from purchases?		How much did you spend to purchase [ITEM] in total?	How much [ITEM] came from own-production?		How much [ITEM] came from gifts and other sources?	
					IF NONE WRITE 0 FOR QUANTITY		THIS QUESTION REFERS TO THE QUANTITY SPECIFIED PREVIOUSLY	IF NONE WRITE 0 FOR QUANTITY		IF NONE WRITE 0 FOR QUANTITY	
		1 YES 2 NO ▶NEXT LINE									
	Food item		QUANTITY	UNIT [SEE CODE PAGE]	QUANTITY	UNIT [SEE CODE PAGE]	KSH	QUANTITY	UNIT [SEE CODE PAGE]	QUANTITY	UNIT [SEE CODE PAGE]
ID	J1	J2	J3a	J3b	J4a	J4b	J5	J6a	J6b	J7a	J7b
Meat, meat products, fish											
0801	Goat meat										
0802	Beef including minced sausage										
0803	Pork including sausages and bacon										
0804	Chicken and other poultry										
0805	Wild birds, insects										
0806	Other domestic meat products										
0807	Bushmeat										
0808	Eggs										
0809	Fresh fish and seafood										
0810	Dried/salted fish and seafood										
0811	Package/Canned fish										
0812	Other meat										
Milk and milk products											
0901	Fresh milk										
0902	Milk products										
0903	Canned milk/milk powder										
0904	Other dairy products										
Oil and fats											
1001	Cooking oil										
1002	Butter, margarine, ghee										
1003	Other fat products										
Spices and other foods											
1101	Salt										
1102	Other spices										
Beverages											
1201	Tea dry										
1202	Coffee and cocoa										
1203	Bottled/canned soft drinks (soda, juice, water)										
1204	Prepared tea, coffee										
1205	Bottled beer										
1206	Local brews (e.g., komoni)										
1207	Wine and spirits										

MODULE K HOUSEHOLD NON-FOOD EXPENDITURE

D:A. Household non-food monthly expenditure

	K1	K2	K3
Item ID	Item name	In the **last 30 days** did your household spend money on [item] ?	Amount spent on [item] in the **last 30 days**?
		1 = Yes 0 = No	KSh
		if 0 => next [item]	
1	Fuel (firewood, charcoal, kerosene, gas)		
2	Transport expenses		
3	Communication (cell phone, calling)		
4	Entertainment (TV, vacation)		
5	Utilities and taxes (electric bill, water)		
6	Other, specify		

D:B. Less frequent expenditures

	K4	K5	K6
Item No	Item name	In the past **12 months**, did your household spend money on [item] ?	What was your household's total expenditure on [item] over the **last 12 months**?
		1 = Yes 0 = No	KSh
		if 0 => next [item]	
1	Clothes and shoes (including school uniforms)		
2	School fees and other educational expenses		
3	Social events (wedding, funeral, harambe, etc)		
4	Housing improvement (lantrine, new roof, etc)		
5	Human Health expenses (medication,consultation, hospitalization)		
6	Other1, specify		
7	Other2, specify		

SECTION L SUBJECTIVE WELFARE AND FOOD SECURITY

ASK BOTH WOMAN AND MAN IN THE HOUSEHOLD.

NOTE: IF THE HOUSEHOLD HAS FASTED IN THE PAST 7 DAYS THEN ASK THE RESPONDENT TO REFER TO A TYPICAL WEEK WHEN ANSWERING THESE QUESTIONS.

In the past 7 days, did you worry that your household would not have enough food? 1 YES 2 NO	In the past 7 days, how many days have you or someone in your household had to: IF NO DAYS, RECORD ZERO. Rely on less preferred foods? DAYS	Limit the variety of foods eaten? DAYS	Limit portion size at meal-times? DAYS	Reduce number of meals eaten in a day? DAYS	Restrict consumption by adults for small children to eat? DAYS	Borrow food, or rely on help from a friend or relative? DAYS	Have no food of any kind in your household? DAYS	Go a whole day and night without eating anything? DAYS
L1	**L2a**	**L2b**	**L2c**	**L2d**	**L2e**	**L2f**	**L2g**	**L2h**

Imagine a 5-step ladder where on the bottom, the first step, stand people living in very bad econonic conditions, and the highest step, the fifth, stand people living in very good economic conditions On which step do you place your present economic conditions? 1 Very bad 2 Bad 3 Neither good nor bad 4 Good 5 Very good	let me ask about the social relationships in the community Does any of your household members voluntarily participate in each of the following kinds of network groups in the last 12 months? 1 Women group 2 Youth group 3 ROSCA/table banking 4 Funeral savings group 5 Fermers group 6 Others 7 None
L3	**L4**

How often did agricultural development/ extension agent visit your farm during Mar 2016-Mar 2017 season to give you advice on farming? 1= at least one every week / 2= not weekly but at least once every month / 3= not every month but at least once during the cropping season/ 4 = Just once / 5 = never	How often did you visit agricultural development/ extension agent during the Mar 2016-Mar 2017 season to get advice on farming? 1= at least one every week / 2= not weekly but at least once every month / 3= not every month but at least once during the cropping season/ 4 = Just once / 5 = never
L5	**L6**

SECTION M. Credit Status

				(If answer to M3 is greater than zero) What percent of the total amount in M3 did you ACTUALLY use for each of the following purposes? (Answer more than one if necessary)? Instruction: sum of all percentages should be 100%								(PROGAMMER: THIS QUESTION SHOULD BE ASKED ONLY IF AMOUNT IN M3 IS LESS THAN AMOUNT IN M2) What do you believe are the you did not borrow the total amount of credit that was offered to you?								
Local banks, cooperatives or grain buyers evaluate your creditworthiness and offer you a loan without you requesting a loan.	You must formally request a loan from banks/cooperatives/grain buyers.	Did you accept the offer from your banks, cooperatives or grain byers?	(If answer to M1a is TRUE) On the most recent loan, approximately how much did your bank/cooperative/ buyer OFFER to lend you?	Of the amount offered in M2, how much loan (Tzs) did you ACTUALLY borrow (Do not leave blank. Put 0 if no loan was used, If the amount actually used is not known, put 9999)	Agricultural production	House construction/renovation	Purchase of car/motorcycle/bicycle	Household consumption	Medical expenses	Education expenses	Other purposes	I do not need loan/I do not invest	I have own money and saving to invest	I borrow from friends	Interest rate is too high	I am afraid of loosing collateral/ assets	I am not credit worthy	I can not get a guarantee	Terms of the loan are not flexible enough to meet my ability to repay	Cost of loan application is too high
1 TRUE 2 FALSE Programmer: If the answers to both M1a and M1b are FALSE skip to M14a	1 TRUE ►M7 2 FALSE	1 Yes 2 No ►M14a	KES	KES IF 0 ► M5a	%	%	%	%	%	%	%	0 N/A 1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	0 N/A 1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	0 N/A 1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	0 N/A 1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	0 N/A 1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	0 N/A 1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	0 N/A 1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	0 N/A 1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	0 N/A 1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important
M1a	**M1b**	**M1c**	**M2**	**M3**	**M4a**	**M4b**	**M4c**	**M4d**	**M4e**	**M4f**	**M4g**	**M5a**	**M5b**	**M5c**	**M5d**	**M5e**	**M5f**	**M5g**	**M5h**	**M5i**

major reasons						(If answer to M10 is Yes) For what purposes you used the offered loan (answer more than one if necessary)? Instruction: sum of all percentages should be 100%							(If answer to M10 is No) Why didn't you accept the offered loan (answer more than one if necessary)?							(If answ
Branch is too far away	Do you think your collateral/land/asset was enough to secure a loan amount higher than the amount identified in M3?	(If answer to M1b is TRUE) Have you applied for a loan from your bank/cooperative/buyer within past 2 years?	(If answer to M7 is YES) On the most recent loan request approximately how much loan did you request?	How much money did your bank/cooperative/ buyer offer you?	(If answer to M9 is greater than zero) Did you accept the offered loan?	Agricultural production	House construction/renovation	Purchase of car/motorcycle/bicycle	Household consumption	Medical expenses	Education expenses	Other purposes	The amount of offered loan is too little for what I planned to invest	I borrowed from friends instead	Interest rate is too high	I am afraid of losing collateral	Loan products are not flexible enough to meet my ability to repay	Branch is too far away	Do you think you have sufficient collateral to secure a higher loan amount than you identified in M9?	I do not need loan/I do not invest
0 N/A 1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Yes 2 No SKIP TO NEXT SECTION (N)	1 Yes 2 No ►M14a	KES	KES zero if loan fully denied	1 Yes 2 No ►M12	%	%	%	%	%	%	%	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Yes 2 No 99 Not sure SKIP TO N16	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important
M5j	**M6**	**M7**	**M8**	**M9**	**M10**	**M11a**	**M11b**	**M11c**	**M11d**	**M11e**	**M11f**	**M11g**	**M12a**	**M12b**	**M12c**	**M12d**	**M12e**	**M12f**	**M13**	**M14a**

ver to M7 is No) Why you have not applied for loan from your grain buyer or bank in the last 2 years (answer more than one if necessary)?

CREDIT IMPACT Enumerator: 'borrowing constraint' means difficulty in obtaining loans from a bank, cooperative, grain buyer or other sources.

I have own money and saving to invest	I borrow from friends	Interest rate is too high	I am afraid of loosing collateral/ assets	I am not credit worthy	I can not get a guarantee	Terms of the loan are not flexible enough to meet my ability to repay	Cost of loan application is too high	Branch is too far away	Do you think the costs associated with loan application are too high or too much paper work or the bank is too far away?	(If answer to M13 is No or Not sure) assuming that you had sufficient collateral to secure any amount of loan that you need to borrow. Would you borrow more?	If you need money but are unable to borrow, you would reduce agricultural input use	If you need money but are unable to borrow you would look for off-farm employment.	If you need money but are unable to borrow, you would not be able to afford good education for your children.	If you need money but are unable to borrow, you would not be able to afford adequate health care for your family.	If you need money but are unable to borrow, your family would not be able to get enough food throughout the year.	If you need money but are unable to borrow, you will sell your asset, including livestock, jewelry, and other household utensils.	If you need money but are unable to borrow, you or family members would migrate to other places.	If you could get as much loan as you would like to get at affordable interest rate, , which of the following would you agree the most? (Choose only one)
1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Unimportant 2 Of little importance 3 Moderately important 4 Important 5 Very important	1 Yes 2 No 99 Not sure	1 Yes 2 No 99 Not sure	1 =strongly disagree 2 =disagree 3 =undecided 4 =agree 5 =strongly agree	1 =strongly disagree 2 =disagree 3 =undecided 4 =agree 5 =strongly agree	1 =strongly disagree 2 =disagree 3 =undecided 4 =agree 5 =strongly agree	1 =strongly disagree 2 =disagree 3 =undecided 4 =agree 5 =strongly agree	1 =strongly disagree 2 =disagree 3 =undecided 4 =agree 5 =strongly agree	1 =strongly disagree 2 =disagree 3 =undecided 4 =agree 5 =strongly agree	1 =strongly disagree 2 =disagree 3 =undecided 4 =agree 5 =strongly agree	1 Leave agriculture and start a non-farm enterprise 2 Leave agriculture and work as off-farm labor 3 Remain in agriculture and expand agricultural production 4 Remain in agriculture and also start a non-farm enterprise 5 None of the above
M14b	**M14c**	**M14d**	**M14e**	**M14f**	**M14g**	**M14h**	**M14i**	**M14j**	**M15**	**M16**	**M17a**	**M17b**	**M17c**	**M17d**	**M17e**	**M17f**	**M17g**	**M18**

Section N: Experiment on risk preference

Enumerator: Take printout of the lottary page

N1	N2a	N2b	N3
Would you like to exchange your 300 Ksh credit reward with any of these five gamess?	If Yes, select the lottery ticket that was chosen (from the options 1 to 5)	What is the reward amount?	What is your phone number (if available)
If the Answer is NO, give the household 300 Ksh and thank them for participating.			
1 Yes, 2 No	Select (1, 2, 3, 4, or 5)	Ksh	

Let me introduce you to a game, whose value depends on the outcome of a coin. I am going to flip a coin. In each lottery, if the coin lands on head, you will win the amount below the picture of head. If the coin lands on tail, you will then win the amount below the picture of tail of this coin.

To thank you for your time and patience with us today, I would like to offer you 300 Ksh as a token of appreciation for taking time to participate in this interview. You can opt to exchange your 300 Ksh with one of the five options tickets below, which may allow you to earn from 0-1200 Ksh, depending on your choice of options and your luck. The total amount of reward you will get will depend on the outcome of the options you choose, which will depend on the outcome of a coin that I am going to flip.

1. 

300 Ksh 300 Ksh

2. 

480 Ksh 270 Ksh

3. 

600 Ksh 240 Ksh

4. 

900 Ksh 120 Ksh

5. 

1200 Ksh 0 Ksh

Appendix 2 - Multinomial Logit determinant regression results with only three rationing groups.

VARIABLES	price	Quantity_rationed	Risk_rationed
age		0.005	0.006
		(0.359)	(0.270)
education		-0.024	-0.052*
		(0.356)	(0.081)
female		-0.454	0.170
		(0.148)	(0.364)
hh_adults		-0.178	-0.063
		(0.197)	(0.397)
hh_size		0.128	0.053
		(0.148)	(0.302)
total_acres		0.001	-0.035*
		(0.938)	(0.064)
maize_per_acre		-0.000	-0.000
		(0.497)	(0.362)
plots		-0.122	0.050
		(0.277)	(0.515)
ownership		-0.112	-0.324
		(0.809)	(0.379)
ave_dist		-0.000	-0.099
		(0.998)	(0.517)
productive		-0.029**	-0.022***
		(0.011)	(0.008)
l_income		0.005	-0.018
		(0.806)	(0.577)
percent_food		-0.718	0.371
		(0.330)	(0.175)
sub_welfare		-0.359*	-0.136
		(0.071)	(0.137)
ra		0.037	-0.018
		(0.690)	(0.686)
Constant		0.220	0.648
		(0.862)	(0.236)
Observations	1,144	1,144	1,144
Robust pval in parentheses *** p<0.01, ** p<0.05, * p<0.1			

Appendix 3 – Determinant logit regression results for a combined constrained group that combines both the quantity and risk rationed.

VARIABLES	constrained
age	0.006
	(0.238)
education	-0.046*
	(0.061)
female	0.060
	(0.741)
hh_adults	-0.089
	(0.126)
hh_size	0.069*
	(0.096)
total_acres	-0.021
	(0.262)
maize_per_acre	-0.000
	(0.282)
plots	0.009
	(0.902)
ownership	-0.284
	(0.393)
ave_dist	-0.078
	(0.578)
productive	-0.024***
	(0.003)
l_income	-0.011
	(0.647)
percent_food	0.140
	(0.592)
sub_welfare	-0.185*
	(0.066)
ra	-0.006
	(0.902)
Constant	1.097*
	(0.081)
Observations	1,144
Robust pval in parentheses *** p<0.01, ** p<0.05, * p<0.1	

Appendix 4 – Uptake logit results using only a constrained variable that combines both the quantity rationed and risk rationed groups as well as combines the price and transaction cost rationed groups.

VARIABLES	uptake
constrained	-0.049
	(0.824)
rcc	0.257
	(0.202)
rcc75	-0.322
	(0.479)
rcc50	0.202
	(0.605)
rcc25	0.386
	(0.212)
age	-0.005
	(0.548)
education	0.015
	(0.671)
female	-0.201
	(0.316)
hh_adults	0.059
	(0.463)
hh_size	-0.024
	(0.572)
total_acres	-0.012
	(0.255)
maize_per_acre	0.001**
	(0.028)
productive	0.004
	(0.502)
percent_food	-0.560
	(0.168)
sub_welfare	0.102
	(0.329)
Constant	-0.876
	(0.229)
Observations	816
Robust pval in parentheses *** p<0.01, ** p<0.05, * p<0.1	

Appendix 5 – Uptake logit regression results, with only those offered RCC and Normal Credit as a robustness check.

VARIABLES	RCC	Normal Credit
risk	-0.279	-0.000
	(0.483)	(1.000)
quantity	-0.220	0.259
	(0.549)	(0.407)
trans	-1.376**	-0.367
	(0.048)	(0.477)
age	-0.001	-0.007
	(0.876)	(0.535)
education	-0.007	0.051
	(0.873)	(0.293)
female	-0.152	-0.398*
	(0.556)	(0.054)
hh_adults	0.025	0.127
	(0.805)	(0.450)
hh_size	0.004	-0.071
	(0.936)	(0.392)
total_acres	-0.004	-0.045
	(0.512)	(0.170)
maize_per_acre	0.001	0.001*
	(0.276)	(0.075)
productive	-0.012	0.030***
	(0.446)	(0.002)
percent_food	-0.493	-0.337
	(0.394)	(0.546)
sub_welfare	0.172	0.032
	(0.206)	(0.821)
Constant	-0.663	-1.116
	(0.567)	(0.268)
Observations	466	350
Robust pval in parentheses *** p<0.01, ** p<0.05, * p<0.1		

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